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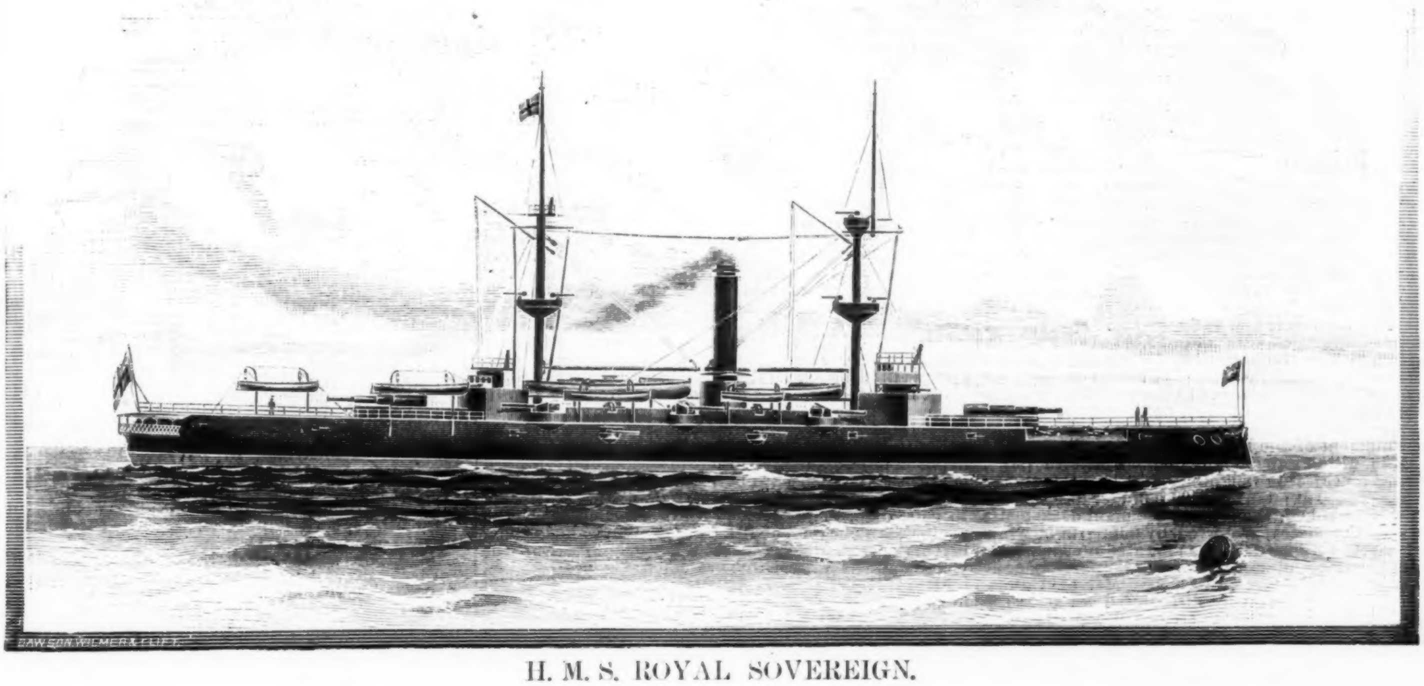
THE ROYAL SOVEREIGN.

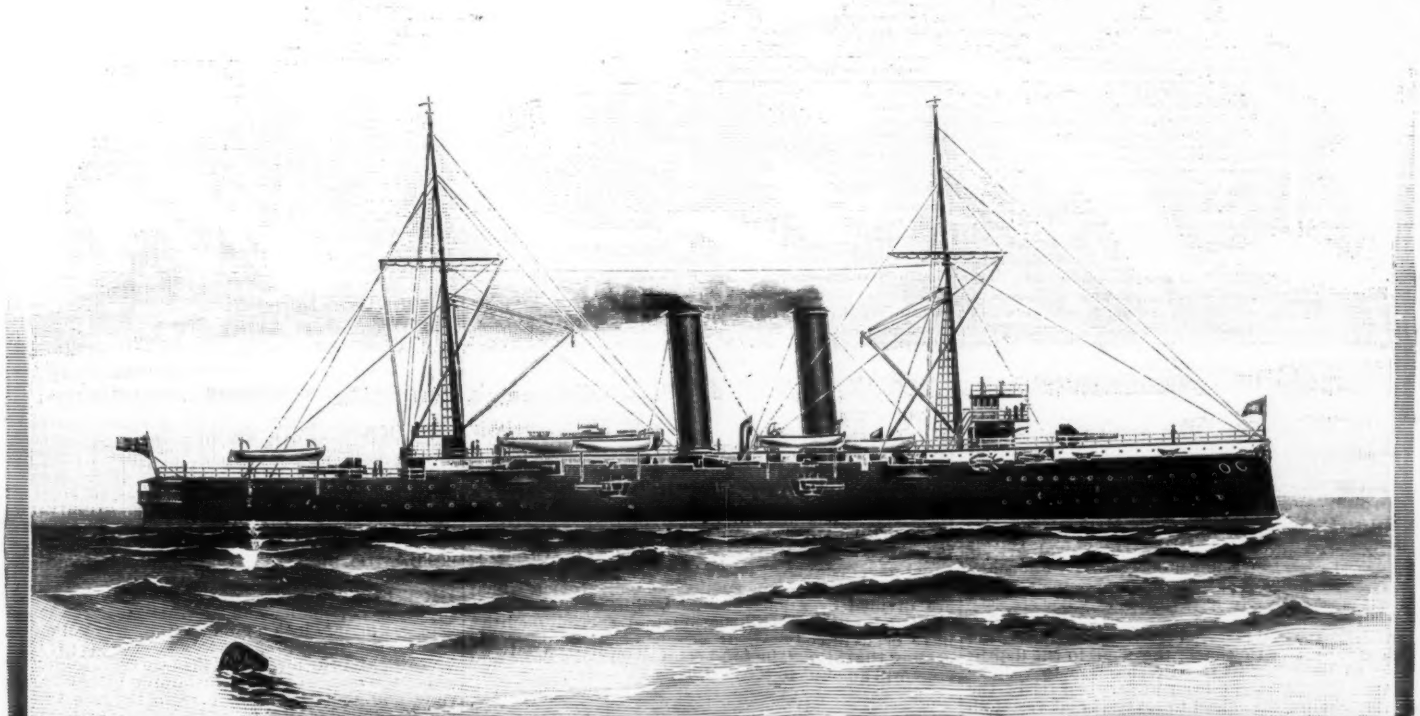
THE floating of the great battle ship Royal Sovereign was successfully carried out in the presence of her Majesty the Queen at Portsmouth upon the 26th of February.

The Royal Sovereign is the largest battle ship hitherto constructed for the British Navy, and forms one of eight ordered to be built under the Naval Defense Act—four in the Royal dockyards and as many by contract. The names of the others are the Hood, Renown, Repulse, Ramillies, Resolution, Revenge, and Royal Oak, the whole of which are barbettes, with the single exception of the Hood, which is a turret ship. The dimensions of the Royal Sovereign are: Length, 380 ft.; breadth, 75 ft.; draught—mean, 27 ft. 6 in.; displacement, 14,150 tons; freeboard—forward, 19 ft. 6 in., aft 18 ft.; I.H.P.—Natural draught, 9,000, forced draught, 13,000; speed—natural, 16 knots, forced, 17½ knots; coals carried at the designed load draught, 900 tons; coal endurance at 10 knots, 5,000 miles; total weight of armament, 1,410 tons; weight of auxiliary ditto, 500 tons; height of heavy guns above water line, 23 ft.; length of belt, 250 ft.; greatest thickness—side armor, 18 in., protective deck, 3 in.; total weight of armor and backing, including protecting deck, 4,550 tons.

As befits her enormous bulk and weight, the construction of the ship has been made exceptionally strong. The hull alone absorbs not less than 9,640 tons of the total displacement, and of that amount about 7,200 tons has been worked into the structure since the keel plate was laid down on October 1, 1889, up to the time of the floating out of dock, a period of less than seventeen months. This is a record of progress which is believed to be wholly beyond precedent either in a government or in a private yard. And this remarkable advancement is all the more creditable to the Portsmouth establishment, seeing that the Royal Sovereign was built in the open, and that work had frequently to be suspended in consequence of the very severe winter. She is built of entirely of mild steel, as



H. M. S. ROYAL SOVEREIGN.



H. M. S. ROYAL ARTHUR.

are now all ships in the service, the stem and stern posts and shaft brackets being also formed of steel castings. The flat pieces of keel are composed of plates ¾ in. in thickness, while the vertical keel has a thickness of ⅝ in., with a maximum height of 5 ft. amidships, diminishing to 3 ft. 6 in. at the first longitudinal, and tapering toward the extremities. A novelty has been introduced in this portion of the structure, as the vertical keel is perforated to allow the water to pass freely between the first watertight longitudinals. Above there is a second watertight longitudinal on the port and starboard sides, so that, as a matter of fact, the whole hull from end to end is largely subdivided, for the purpose of minimizing to the fullest possible extent the risk of danger to the bottom plating from rocks or torpedoes. The frames have also been specially designed with reference to the great weight to be carried, and additional stiffness is secured by double longitudinal bulkheads, which not only form a passage for easy communication below the water-line from end to end, but support the middle portions of the hull when the ends are simultaneously elevated by waves. A protective steel deck, 2½ in. in thickness extends under water from the bow for about 76 ft. and from the stern for a distance of about 73 ft. From this deck, and resting upon an armor shelf, is built a belt of steel-faced armor with a backing of teak. The lower edge of the belt extends 5 ft. 6 in. below the low draught line, while the upper edge is carried 3 ft. above the line. The greatest thickness is 18 in., the belt itself extending over a length of 250 ft. out of a total length of 380 ft., and terminating in armored bulkheads. At the fore and after ends of the belt, and rising directly from the protective deck, are the barbettes, formed of armor 17 in. thick. Superimposed upon the thick belt is placed another belt of light armor, 4 in. thick at the sides and 3 in. thick on the screens, running across the ship; and behind this side armor coal-bunkers are arranged, whereby a large amount of additional protection is secured. Over the armor belt there is also a 3-in. steel deck, worked so that horizontal deck protection extends from end to end. Objection has been taken to the fact that the side armor stops short at the auxiliary battery. It remains, however, to be stated that, while the side of the ship at this part is wholly unprotected, the guns are protected by 6 in. screens and the crews by armored emplacements. And in order to procure a safe passage for the ammunition from the several magazines to the guns of the secondary armament, armored tubes have been specially fitted. It is also to be noted that, with a view of preventing water from finding its way below the protective deck, means are provided for closing the several openings by watertight covers, while in the case of those which must necessarily remain open, coffer dams have been fitted with the same object. The Royal Sovereign will be completed for the use of an admiral. She will be lighted throughout with an installation of over 600 electric lights, and she will also be equipped with four electric search-lights of 25,000 candle power, each of which will be worked by dynamos under protection. The ship in action will be fought from either of two conning towers, of which the forward one is armored to the extent of 14 in. and the after one to 3 in.

The armament of the Royal Sovereign will comprise four 13½ in. 67-ton guns mounted *en barbette* in pairs, and firing a projectile weighing 1,250 lb. with a powder charge of 630 lb.; ten 6-in. 100 pounder quick firing guns, double banked, the four on the main deck being mouted in casemates protected by 6 in. armor, while the six on the upper deck are mounted on sponsons; 16 6-pounder and nine 3 pounder quick firers, eight small machine guns, and two 9 pounder field guns. The auxiliary armament is distributed all over the ship, and extends from bow to stern, the top sides and bridges having a considerable number disposed upon them. The main armament is worked by hydraulic machinery supplied by Sir William Armstrong & Co. The other guns are all worked by hand, the 6 in. by one man, others being employed for feeding purposes. The ship is also fitted with seven torpedo tubes, of which two are submerged. The number of torpedoes carried is 18.

The engines are provided by Messrs. Humphrys, Tennant & Co., who have also the contracts for the whole of the dockyard ships of the class. They are of the triple expansion vertical type now becoming general in the service, and are to indicate 9,000 H. P. with natural draught and 13,000 with forced draught, producing speeds of 16 and 17½ knots respectively on a weight of 14,150 tons. This noticeable increase of efficiency as compared with other battle ships is in a great measure due to the difference in form, which was adopted as the best after a series of model experiments by Mr. Froude, at Haslar.

The new ship is designed to carry 900 tons of coal, which, at a uniform speed of 10 knots, is estimated to steam her 5,000 knots. The arrangements for fuel are similar to those in the Trafalgar; but, whereas any increase above 900 tons in the coal put on board that ship necessitates an increased draught and some loss of speed, in the Royal Sovereign provision is made (in the form of the "Board margin") for an unappropriated weight which will enable 50 per cent. more coal to be carried at the designed load draught and at the full speed. The ship's companies consist of 700 officers and men.

The Royal Sovereign has been built from the designs of Mr. W. H. White, Director of Naval Construction, under the direction of Mr. H. E. Deadman, Chief Constructor, and Mr. L. G. Davies, Constructor, with Mr. Taylor in charge.—*Marine Engineer.*

H. M. S. ROYAL ARTHUR.

THE first-class protected cruiser the Royal Arthur was launched from Portsmouth dockyard on February 26th. The ceremony of christening and launching the vessel was most successfully performed by her Majesty the Queen.

After the Queen had received instructions concerning the buttons she was to touch, the men in the depths below set to work with the battering ram to remove the last remaining blocks from under the keel of the ship. A few minutes sufficed to set the great vessel all but free, a formal report that all was in readiness was given to Admiral Gordon, an electric bell rang, a bugle sounded, and her Majesty touched the first button. As the bottle thus released crashed against the stem, her Majesty wished "Success to the Royal Arthur." In a moment or two the second button was touched, the cord was severed, the weight fell, and, amid a tumult of cheers, in which all joined who were present, royal princes vying with more lowly subjects, the great vessel glided rapidly out upon the water. The cheering was renewed again and again from the inside of the shed, from the crowd without in the dockyard, from the upper works of the vessel herself, which were covered by men who had been in concealment below, and from the multitudinous small craft upon the harbor waters. Through the cheering could be heard the thundering salute of the Wellington's guns and, but more faintly, the music of the band of the Inniskilling Fusiliers as they played "Rule Britannia." A more successful launch was surely never seen, nor a nobler sight than the Royal Arthur as her anchors bit the ground and she rode to them for the first time in Portsmouth Harbor.

The keel plate of the Royal Arthur, first class protected cruiser (originally named the Centaur), was laid down on the 20th of January, 1890, and when it is stated that, of the 4,400 tons of weight which are absorbed by the shell alone, 2,600 tons have been actually worked into the ship, it will be seen that she has been advanced with remarkable rapidity. She forms one of a squadron of nine ships of the class for which provision was made under the Naval Defense Act. The names of the others are the Crescent, Edgar and Hawk, building in the dock yards; and the Endymion, Gibraltar, Grafton, St. George, and Theseus, building by contract. To speak strictly, however, the Royal Arthur and the Crescent (which is also under construction at Portsmouth) differ slightly from the rest of the class. When the former was well advanced, progress at the bow was arrested, with a view to modifications being introduced, and it was finally determined, and wisely, to add a topgallant forecastle in the two ships, with a trifling change of armament as a necessary consequence. On our first page will be found an illustration of this vessel.

The Royal Arthur measures 360 ft. between perpendiculars and 60 ft. 8 in. beam, with mean draught of 24 ft. 9 in. and a load displacement, when fully equipped for sea, of 7,700 tons. With the exception of the Royal Sovereign, she is the largest ship ever launched from the Portsmouth yard, her stem and stern projecting far beyond the ends of the slip on which she was constructed. The new cruiser is built entirely of steel, having large phosphor bronze castings for stem and stern posts, shaft brackets, etc., the form of the bow constituting a ram of formidable character. The double bottom, which runs throughout the ship and extends from the wing passages on each side, is constructed on the usual cellular bracket system, and is subdivided by the longitudinal and transverse framing into a great number of watertight compartments, as a protection against underwater attack.

The framing of the structure is of great strength, and is further strengthened by cross bracing. The vital portions, such as the engines and boilers, magazines, and steering gear, are protected by a steel deck of the ordinary turtle back form, with sharp curves at the sides, and extending throughout the structure. It varies in thickness from an inch to a maximum of 5 in. in places most exposed to injury in action, and is topped next the skin of the ship by broad coal bunkers, which afford supplementary defense against shot and shell. In consequence, however, of the great height of the engines, which renders it impracticable to keep them below the steel deck, the cylinders (which are in the vicinity of the water line) are efficiently protected on both sides by sloping armor or coamings 6 in. in thickness.

The arrangements for the protection of the guns and gun crews consist of casemates with screens in front, which move with the training of the guns, and are of the thickness of 6 in., which is supposed to be amply sufficient to prevent the bursting of shell inside. Inboard the gunners stand within an iron box 2 in. in thickness, through the door of which the shot and ammunition are served, by means of tubes, with great ease and rapidity. The ship is also fitted with an armored conning tower forward, 12 in. thick, from which, in action, the engines, steering gear, and guns can be directed. She will be ventilated by both natural and artificial means, and will be lighted electrically throughout. Four search lights for protection and use in torpedo attack will be provided, and worked by machinery under cover of the steel deck. Auxiliary means of illumination will also be supplied. Among other fittings are a special canteen, a drying room, and steam hoists for getting the boats (which are the same as in a first class battle ship) freely in and out.

The Royal Arthur will carry the following modified armament: One 9·2 in. gun (carried on central pivot mounting aft), 12 6-in. quick firing guns, 12 6-pounder quick firers, 5 3-pounders, 6 machine guns, and 2 9-pounders—a remarkable armament for a cruiser. In addition to the above the ship is fitted with four torpedo tubes of the largest design, two submerged and two above water, with a complement of 18 torpedoes. A complete system of net defense will be supplied as a safeguard against torpedo attack, in conjunction with the employment of her own torpedo guns and boats.

The ship is fitted with twin screws and a balanced rudder (worked either by steam or hand), her high speed requiring this special form of rudder to keep her under proper control. The engines will be supplied by Messrs. Maudslay, Sons & Field, of Lambeth. The contracted I. H. P. is 10,000 horses with natural draught and 12,000 with forced draught, which, it is estimated, will give a speed of 18¾ and 19½ knots respectively. The amount of coal carried is 850 tons, which will enable the ship to steam continuously at a 10 knot speed over a radius of 10,000 knots, which is equal to a distance of 11,500 miles, or 2,800 knots at a speed of 18 knots. The engine and boiler rooms, which are divided by a longitudinal bulkhead, possess exceptional means of ventilation, and special facilities have been introduced, by means of sector ports, for coaling the ship. The total complement of officers and crew will amount to 520.—*Marine Engineer.*

There is a great subject for study in Philadelphia. A surgeon there has dissected and mounted the complete nervous system of a human being, something never before accomplished.

THE BUILDERS OF THE STEAM ENGINE—THE FOUNDERS OF MODERN INDUSTRIES AND NATIONS.*

By Dr. R. H. THURSTON, Director of Sibley College, Cornell University.

THERE can be, as it seems to me, no more fruitful and interesting subject of investigation and study, in the history of the race, than that which notes the influence of the earlier and the later methods in philosophy upon the material progress of the world; and which observes the result of the introduction of great inventions into the midst of a society, on the one hand, absolutely without sympathy for that inclination which stimulates the contriver, and without ambition to avail itself of the advantages offered by his inventions, or, on the other hand, among people hungry for them, and for the advantages which they promise.

Of this difference between the older and younger civilizations, between Greek and Roman and modern Anglo-Saxon, no better illustration can be found than in the History of the Growth of the Steam Engine. Known two thousand years or more ago, it was made a toy by the speculative and unutilitarian Greek; tendered by Watt to a modern world, it is made the foundation of all material, and even of intellectual, progress. Greece and Rome, like their predecessors, Babylon, Nineveh, Thebes, and Karnak, reaching a certain point in their civilization, stood comparatively at rest, and presently only changed to retrograde, while handing on their civilization to later representatives of human advancement.

The world of the nineteenth century moves on with a mighty and accelerated velocity, gaining more in a century than mankind had advanced in its whole previous history.

It is to science, pure and applied, that the world owes all these wonderful advances that we are witnessing now, even more than inthe immediate past. It is to the *truth-loving* quality of science that we owe the recent rapid growth of the arts. Only the exact truth is sought, and everything yields to fact. "For her the volume of inspiration is the book of nature, of which the scroll is ever spread before the eyes of every man. Confronting all, it needs no societies for its dissemination. Infinite in extent, eternal in duration, human ambition and human fanaticism have never been able to tamper with it. On the earth it is illustrated by all that is magnificent and beautiful; on the heavens its letters are suns and worlds." The study of science, directed, as it usually seems to be, to the improvement of the physical condition and the surroundings of man, actually leads, very directly and promptly, to the improvement of his moral and intellectual character. It gives him the means of performing all necessary work in a shorter time than formerly, and thus sets free the intellect and the soul to carry on *their* highest work. The applications of science to the useful arts not only give us better and cheaper clothing, a greater variety of wholesome food, and means of rapid and easy transportation; but permit man to think out, in more and more frequent leisure moments, occasional leisure hours, the problems of life, to adjust himself better to his environment, to consider the needs of his fellows, to find opportunity for exercise of his sympathies, to improve his intellectual powers, to acquire knowledge on which to exercise them, to think out the great moral problems of life and of death, and to thus ascend into a higher and better atmosphere, a nobler sphere in the boundless universe of mind.

No one has summarized the work of science in this century better than Macaulay: "It has lengthened life; it has mitigated pain; has extinguished diseases; has increased the fertility of the soil; given new security to the mariner; furnished new arms to the warrior; spanned great rivers and estuaries with bridges of form unknown to our fathers; it has guided the thunderbolt innocuously from heaven to earth; it has lighted up the night with splendor of the day; it has extended the range of human vision; it has multiplied the power of the human muscles; it has accelerated motion; it has annihilated distance; it has facilitated intercourse, correspondence, all friendly offices, all dispatch of business; it has enabled man to descend to the depths of the sea, to soar into the air, to penetrate securely into the noxious recesses of the earth, to traverse the earth in cars which whirl along without horses, to cross the ocean in ships which run many knots an hour against the wind. These are but a part of its fruits, and of its first fruits; for it is a philosophy which never rests, which is never perfect. Its law is progress. A point which yesterday was invisible is its goal to-day, and will be its starting point to-morrow."

The intellectual, and largely the moral, progress of mankind depends, in very great degree, upon the material progress of the race; but this, in turn, is the product of the labors of the inventor and of the laboring classes. The gain of wealth, on which we must inevitably and always depend for any real and permanent advance, in whatever field, must inevitably and always in turn depend upon two principal results of the work of the engineer's, the inventor's, the mechanic's brain: (1) The reduction of the cost, in money or in labor, as the best gauge of those necessaries of life and of progress which are, in their use, subject to destruction—such as food, clothing, protection from the weather. (2) The rapid and permanent accumulation of the permanent forms of wealth such as constitute the real measure of prosperity, and give to a nation the comforts and luxuries which are either essential or conducive to leisure and thought, to intellectual development and moral growth. Poverty and enforced asceticism give unquestionably large opportunity for the development of certain phases of the strongest characters; but only leisure and voluntary asceticism can produce the highest development of character and mental growth combined.

It is to the producer of every facility for the cheap supply of perishable and destructible necessaries that we must mainly look for aid in the laying of a foundation for continual progress in higher fields; it is to the inventor and the mechanic that we must appeal mainly for the means of easily sustaining life while seeking time and opportunity to give to the race the means and the opportunity to advance to a higher plane in civilization and mental existence. It is the wonderful

* An address delivered at the Centennial Celebration of the American Patent System, Washington, April, 1891.

result of the work of the inventor in the past century, largely stimulated by modern scientific knowledge, and perhaps even more by modern methods of legal encouragement of the inventor, and of assuring to him the full possession of the fruits of his brain, that we owe the marvelous gain of a century.

Watt would have accomplished little had he not, at the very start, hit upon the scientific principles of the steam engine; he would have accomplished little, even then, except for the patent system, very probably. He would hardly have had the heart to attempt much even then, nor probably would his financial partner and backer, Matthew Boulton, have felt it safe to invest his capital, no less essential than the invention itself in such an enterprise, had not the new patent system furnished him security for the investment required in shops, tools, and financial operations attendant upon the introduction of the new machine. Machinery and the patent system are the basis of the world's prosperity to-day. Watt made inventions, and the capitalist furnished the means of their construction and use, while the patent system gave security to both inventor and capitalist, and assured them of fair return on their investments of time, thought and money.

As has been often suggested, a new invention is simply the materialization of a new idea of scientific character and useful purpose, an idea capable of supplying to mankind new comforts, new conveniences, new safeguards against want, pain, disease and death. Every new advance, even in pure science, is sure of ultimately finding use in the advancement of the race materially, and indirectly, intellectually and morally. The perfection of a science is the means of perfection of an art, and the improvement of the arts is the direct means of promoting the highest as well as the lower interests of mankind.

It is thus that it has come to pass that "machinery actuated by the forces of nature now performs, with ease and certainty, work that was formerly the drudgery of thousands. Every natural agent has been pressed into man's service: the winds, the waters, fire, gravity, electricity, light itself."

On the shelves of my library stand side by side, as I observed a few days ago—so placed by some curious accident—a copy of the tales of the "Thousand and One Nights" and two or three little volumes of stories of inventors and their inventions, and of modern discoveries. Comparing these two sets of fruits of the human intellect, I find the results of the "scientific use of the imagination," on the whole, far more impressive, and, in many respects, far more marvelous, not to say to the unfamiliar mind more incredible, than those of the romancist.

The military art has always been the sustainer, as it was originally the parent, of the mathematical and physical sciences. The Greek camp and Alexander's army were the progenitors of the great schools of Alexandria. Alexander the Great was the progenitor of the intellectual offspring of Archimedes and of Euclid, as of the theories of Newton; and ancient Greece has been the source of inspiration of all modern life. The polytechnic schools of Alexandria substituted for the speculative methods of Plato the logical philosophy of Aristotle. They employed the reason in place of the imagination in all physical and scientific departments of knowledge. The home of Eratosthenes and of Hipparchus, and of Ctesibus, the instructor of Hero, was the successor of the camp of the Grecian conqueror; and, conquest being ended, real knowledge became the object of ambition. Speculation gave way to investigation, and the triflings and aimless disputations of the older schools were succeeded by the serious labor of research and of the accumulation of real knowledge. This serious and fruitful labor gave an impulse that was never wholly lost, though often seemingly almost extinguished by the combined forces of the political and the military spirit of later times. A thousand years of trifling, the whole period of the dark ages, could not wholly destroy it.

In the history of the world there have been two distinct periods of marked advance, the one mainly philosophical, the other mainly material. These are the times of the Greek philosophers, and notably of the growth and prosperity of the Alexandrian school; and the times which have brought us a modern civilization, the three centuries just closing. The earlier period "died with Hypatia" of Alexandria, and the later began with Newton and is still in full career. Both these periods have been distinguished by a singular freedom of intellectual opinion and growth. In the days of Aristotle, of Sophocles, of Plato, as of Archimedes, of Hero, of the Ptolemies, whatever may be said of the political status of the citizen, his opinions were his own, and his intellectual freedom was absolute; the conflicting sects and philosophies of that time were simply the free growth of mind unrestrained by political or ecclesiastical bonds. In these later days we are just regaining a somewhat similar freedom of intellect, through the all-pervading influence of modern scientific methods and principles. That political freedom which has just begun to come to the citizen of even the monarchies of Europe; that social freedom which has its best illustrations, as well as its most grotesque monstrosities, in the United States; that intellectual freedom which stimulates as well as permits advance in every department of modern life, in science, religion, invention in all the arts: all these forms of freedom are but phases of one mighty development of human progress distinguishing our own time. It is all precisely the same universal unrestraint, coming of a common cause, taking its effect, primarily, in political changes, so far as visible, and marking simply that impulse which is exhibited in any direction in which great forces have been long resisted and restrained, finally to be given vent and thus allowed to expend the long-stored effort in a mighty, and often unanticipated, outburst. The improvement of the steam engine has been one of the consequences of the same train of events which gave England her Magna Charta and the United States a republican form of government; which produced a science of chemistry, and established modern views in astronomy and geology.

The middle ages were periods of repression; the later days have seen the resultant expansion. During their whole extent, the transfer of learning from Alexandria to Bagdad, to Granada; the distribution of Saracen colleges throughout Western Europe; the slumbering of intellect in the countries dominated by the church during those centuries—all were simply the transfer and the storage of energies, the aggregation of the forces of progress, preparatory to their grander action in the days following the martyrdom of Bruno and of Galileo, the events marking the dawning of a new era.

In those older days, when Greek and Roman founded a literature and a philosophy that has been a guide and an inspiration throughout all subsequent times, the inventor and the builder was at a disadvantage; his brain was trameled by the difficulty of getting his ideas crystallized in metal and in wood. To-day he can make whatever he can devise; then he could devise a thousand new instruments, processes, or machines; and not one of the thousand might be practically possible. To-day our progress is only limited by the rate of accomplishment of the brain and its production of representative ideas.

When a stone falls to the ground from a lofty height, it starts from rest with an imperceptible motion, gradually increases its speed by a regular acceleration, and, falling faster and faster, finally reaches the ground with an acquired velocity that can only be compared to that of a cannon shot. The alpine avalanche, slowly sliding along the smooth surface of rocks and soil at the mountain top, exerting a power that a child might successfully oppose, gathers energy as it moves, increasing its speed, storing more and more power as it slides over the declivity, affects larger and larger masses, and, at last, descends into the valley below with the roar of a tempest and the destructive effect of a thousand torrents, moving along with the velocity of a lightning flash. To one who reads the history of the development of civilization among mankind, from the earliest days of the oriental empires to the present, this same universal law of accelerated progress seems to come in play in the origination and perfection of the sciences, the literatures, and the arts. The dawning of civilization among the ancients was but recording in a scanty literature the wanderings, the speculations, the imaginations, of adult children, interspersed with the gossip and tradition of verbal history. Science had no place in their pantology; the arts had only made the most simple beginnings in the provision of the merest necessaries of a most simple life. Progress was hardly perceptible, century by century; the people of one age lived much the same as did those of the preceding; "what was good enough for grandparents was considered good enough for grandchildren," and invention and discovery were words of little import.

Homer probably knew no other literature than the epic; the builders of the pyramids were unacquainted with any other mechanism than the simplest devices called by us to-day the mechanical powers. Hero and the Greeks were familiar with the expansive force of steam, but they had no way of using it in the arts, and their only steam engine was the aelipile, a whirling globe, impelled by the reaction of steam jets. The first principles of scientific method and the simplest facts of science were unrecognized by the people of the time of Christ and the Romans. Menelaus and Achilles took their armies to the coasts of Troy in boats impelled by sails and oars; and their troops fought with arrows and spears. Alexander conquered the world of his time ignorant of gunpowder. Cæsar conquered Gaul and wrote his commentaries unaware of the potentialities of artillery and of the printing press; and the dark ages that intervened, to the times of Galileo and Newton, were unenlightened by even the intelligent anticipation of gas or the electric light.

Our own ancestors of a century or two ago knew absolutely nothing of any one of the most useful inventions or discoveries that seem to us, to-day, to be so essential to our comfort, except the one art of printing. The perfection of the steam engine has been the work of this century; the introduction of the telegraph, the railroad, the steamboat, of the telephone and of the power press, are all the work of mechanics and men of science with whom our own parents and grandparents were acquainted, or who are our own contemporaries. The lever, the wedge and the screw were the great inventions of the ancients; the mariner's compass and the art of printing, the introduction of firearms and artillery were the gauges of the progress of the world in the middle ages, while our own times have seen an innumerable list of inventions contributing to the comfort of humanity and its better life.

To one who has read of the rude beginnings of science and of the arts in the times of the Greeks and Romans, of the oriental civilizations, of the Egyptians and of the Saracens, and who has noted the slow progress of the world through the middle ages, and who has observed the culmination, possibly, of this acceleration in the productive century in which we live; to one who has studied the growth of the steam engine from the toy of Hero of Alexandria, two thousand years ago, through the various rude and ineffective devices of the intermediate centuries, to the time of Worcester, of Savery and of Newcomen, and the wonderful outcome of the work of James Watt; who has seen the steamboat grow from the little craft of the time of Fulton and Stevens to the shape of the floating palaces on Long Island Sound and the great steamer of ten thousand tons burden carrying a thousand passengers across the Atlantic at the speed of a railway train, and the mighty ironclad, almost impenetrable by the heaviest ordnance, and itself throwing tons of steel shot at a broadside miles through the air, starting with a velocity double that of sound itself; to one who has witnessed the development of the railroad from an insignificant beginning only a little more than a half-century ago, two generations at most, to its present state, with its forty, fifty and one hundred ton locomotives, its thousand tons of train, conveying food and comforts across a continent at a cost of less than a cent per ton per mile bringing to the laboring man on the Atlantic coast a barrel of flour a year for each member of his family from Minnesota, nearly fifteen hundred miles away, for less than a dollar, with its magnificent train of palace and sleeping cars rushing from New York to Chicago, a thousand miles, in twenty-four hours, or swinging in tremendous power across the continent to San Francisco in four days; to one who has wondered at the beautiful applications of electric science to the purposes of life and business, as illustrated in the telegraph, transmitting its message in the lightning flash from continent to continent and around the world, or in the telephone, bringing friends, miles apart, *tete-a-tete*, or in the electric light, turning night into day and driving crime into its remotest dens, while giving all the industries the power of doubling their productiveness; and to one who has seen the modern power press printing newspapers by the mile, cutting and trimming them to size, folding and wrapping them for transition to distant readers by a system of mail distribution which equally well illustrates the progress of the age in methods and organization of industries; to one who has perceived all this, the thought must inevitably come that there must be a limit to such speed of advance as we are now witnessing, the law of acceleration must some time cease to operate, and the question must suggest itself: Where is the limit? What is coming in the future of the race? What are the possibilities? What wonders may we expect that science may still discover? What may probably be their effect on the life of the world? What are likely to be the characteristics of the "coming race," of its social life and of its moral, its intellectual, its physical conditions? Bulwer drew upon the imagination of a romancer for his ideal of the future; what may the imagination of a man of science perceive, guided by his more rational view of the past, of the present, and of the general course of progress in invention and discovery?

In all the great operations of nature, the course and the rate of movement are determined by the well-known principle of the "persistence of energy," and by that of the law of Newton, asserting that she invariably endeavors to preserve the existing condition of motion, and that all motion tends to continue uniformly to follow a right line, resisting invariably every tendency to effect a deviation from the existing course with a power which is proportional to the rate at which such deviation from the motion of the moment is forced. Nature never turns a sharp corner, and we may probably as well judge the future of the great intellectual and social movements by the laws of energy as anticipate physical motions.

In writing the history of the "Growth of the Steam Engine," years ago, I divided it into three periods, that of speculation, that of development and application, that of refinement or improvement in detail. The first period is that of Hero and the Greek speculative philosophy; the second that of Watt and his predecessors in the invention of the machine, that of the opening of the modern epoch; and the third is that comprising the whole of the present century, with all its wonders; it is the outcome of the last, the fruit of a minute seed planted in the first of these eras. The men to whom the world is to-day indebted, mainly, for all that it enjoys of material advantage, and for the opportunity to improve it by the intellectual advances which have accompanied the production of modern comforts and luxuries, are, more than any other, Hero of Alexandria, and his contemporary, possibly, Archimedes; Papin, the Marquis of Worcester, Captain Savery, and Newcomen, and, most of all, James Watt. Let us inquire who were these men and what their surroundings, and how they brought about the marvelous changes that the octogenarian of to-day has become familiar with as the outcome of their combined efforts.

Hero was born amid the Greeks at perhaps the most interesting period of their history, philosophically considered. The biography of Alexander, the history of the wars of the Greeks, have little importance or interest in comparison with the life of the earliest engineer, permanently recording the invention of the steam engine, and the history of the intellectual awakening that marked his time. Hero's "Pneumatica" is the first record of invention extant. It only gives us a definite idea of the extent to which the people of that day were familiar with the possible application of the forces of nature to the uses and purposes of mankind. The account is as simple and ingenuous as the devices themselves are simple and undeveloped. It is the description of toys, to which interest attaches only because of their revelation of the condition of ancient useful arts and of the fact that they constitute the germ of mighty inventions of later date. But Hero lived at a time when great inventions were not appreciated, were not even thought of as having possible value in application to the amelioration of the condition of humanity; and were quite impossible of construction, if ever so much desired, because of the fact that no machinery for their construction could then be had. So it happened that the toy steam engine—curiously enough a very perfect type of steam engine, scientifically considered—lay unused, a germ only, like the grain of wheat in the hand of the mummy, for two thousand years, finally to take a new life of wonderful works.

Now and then one of the old philosophers hit, by some happy accident, in the course of his speculations, upon some notion of the nature of heat and energy which was not far from what we now know to be true. But we also have seen that then it was the fact, as Democritus remarked to the old philosopher, "Nothing is true; or, if so, is certain." Knowledge had, in ancient time, no stability; and science, in the modern sense of the term, had no existence. But it was otherwise in the domain of application, and the work of the ancient artisan and the development of the mechanic arts among the old Greeks and Romans and their predecessors of India, Persia and Egypt, command our respect and admiration. When the lack of facilities possessed by the older nations is considered, their success in the construction of their temples, in the erection of the pyramids, in their naval architecture, is to the modern engineer almost as impressive as would many of our grandest achievements be to them, could they return to earth and study the progress made since their own times. No more beautiful edifices are built to-day than existed in the times of ancient civilization; no modern workman can excel in the perfection of his joints and surfaces those observed, still hardly defaced by the centuries, in the great pyramid and its neighbors; the lines of the ancient war galleys, and of the Scandinavian craft, even of the earlier periods, were as fine as those of the finest yachts of our own day. The ancestors of the ancient philosophers honored the artisan, and their gods were the idolized hero-mechanics of earlier times. Labor was rewarded by the greatest honors that the nation could confer. It was not surprising, therefore, that some advances were made, in even those ruder times, in the mechanic arts.

The reasoning of the old philosopher Hero in regard to the physical phenomena involved in the operation of his machines is interesting as illustrating the state of the science in his time. He introduces the description

of the apparatus which has been described by a treatise on the nature of air and the character of the vacuum. He shows that vessels which seem empty are in reality full of air, and proves his assertion by the following considerations and crucial test: "Let the vessel which seems to be empty be inverted into the water. It will be seen that it will not admit the water, although it may appear perfectly vacuous. If a hole be bored in the reversed bottom of the vessel, air will issue and the water will then enter." "Hence, it must be assumed that the air is matter." Further, "if a light vessel with a narrow mouth be applied to the lips, and the air be sucked out and discharged, the vessel will be suspended from the lips, the vacuum drawing the flesh toward it that the exhausted space may be filled. It is manifest from this that there was a continuous vacuum in the vessel." Cupping glasses, which were then already known and in common use, were cited as illustrations of a similar operation, the fire placed in them rarefying the air and the vacuum being thus produced. "Winds are produced by excessive exhalation, whereby the air is disturbed and rarefied, and sets in motion the air in immediate contact with it." "It may, therefore, be affirmed that every body is composed of minute particles, between which are empty spaces less than the particles of the body (so that we erroneously say that there is no vacuum except by the application of force, and that every place is full of ether, air or water, or some other substance), and in proportion as any one of these particles recedes, some other follows it and fills the vacant space; so that there is no continuous vacuum except on the application of some force; and again the absolute vacuum is never found, but is produced artificially." "These things being clearly explained," the author goes on to consider the methods devised for the application of these principles to his purposes.

The fact that none of these contrivances was, so far as the records show, applied to the promotion of the useful arts in the sense in which that application has taken place in modern times, and has thus so wonderfully accelerated the advance of civilization, is probably an indication that the non-utilitarian spirit of the Platonic philosophy, and of the whole learned Greek world, indeed, pervaded the ranks of the people too thoroughly to permit them to profit to any great extent by the inventions of their great mechanicians; who, indeed, seem to have been inclined much more to the gymnastic than to the useful employment of their talents.

This inclination to the display of ingenuity rather than to the promotion of useful arts was transmitted to the Romans also, and the only account extant of such illustrations of the inventive power of that nation are those relating to contrivances of machinery of war, and such curious applications of the genius of the inventor as may have attracted the attention of the classes of leisure and those engaged in scholarly pursuits. Perhaps the only well known example of such ingenious perversion of what might have been useful powers is the following, given us by Gibbon, in his "Decline and Fall of the Roman Empire":

"In a trifling dispute between Anthemius, the architect of Justinian, and Zeno, the orator, relative to the wells or windows of their contiguous houses, Anthemius had been vanquished by the eloquence of his neighbor Zeno; but the orator was defeated in his turn by the master of mechanics. In a lower room, Anthemius ranged several vessels or caldrons of water, each of them covered by the wide bottom of a flexible tube, which rose to a narrow top, and was artificially conveyed among the joists and rafters of the adjacent building. A fire was kindled beneath the caldrons; the steam of the boiling water ascended through the tubes; the house was shaken by the effect of the imprisoned air; and its trembling inhabitants might well wonder that the city was unconscious of an earthquake that they had felt; and the orator declared, in tragic style, to the senate, that a mere mortal must yield to the power of an antagonist who shook the earth with the trident of Neptune."

What has been referred to comprises nearly all that is known, and probably about all that the ancients themselves knew, of the work of their greatest engineers and philosophers in the field here explored. Centuries of strife and hardly ever ceasing wars followed the fall of the Roman Empire, and the arts of peace suffered retardation, rather than advanced. There was, however, an undertow of movement among the more scholarly and the more industrious peoples, and the transfer of the learning of the ancients to the modern time through Saracen dominion, and the progress made by the pagans of the middle ages, were the means of preserving the seed of that later and wonderfully grand outgrowth which has distinguished the three centuries now coming to a close. During this period, also, the Church, which was always the anchor of scholarship, though often the direst foe to science, of real knowledge of the Creator through his works, not only organized its own *materiel* and *personnel* into a most effectively working apparatus for the promulgation of its tenets, but also provided a system of education, and a working educational organization, that, once it was permitted, by that freedom of personal thought which came of the Reformation, to seek knowledge in every field and to accept the logical results of every investigation in science and in morals, became the most effective possible means of promoting true learning. While, therefore, the middle ages seemed to be a period of intermitted growth in all but the science and art of war, it was really a time of readjustment, of rearrangement, of the various classes of Europe, and was preparatory to such a movement of the great underlying forces as should finally give opportunity for the most rapid progress, once that progress should begin on the new lines and in the new ways that distinguished the later period of onward motion of the great current.

A more complete idea of the extent to which the inventive talent of the ancients was fruitful of result in practically useful directions may be gained by studying, in addition to the account of Hero and others of such curious devices as have just been described, those of other authors telling of the various apparatus of war, and for naval purposes, which were invented by the engineers of the Greek and Roman armies and navies. Works on Greek and Roman antiquities describe the rams used for battering down the gates and walls of beleaguered cities, some of them a hundred and twenty feet long, and weighing thousands of pounds, many tons; in fact, so large that it required three hundred pairs of horses or mules to draw them, and fifteen hundred men to operate them when mounted ready for the attack. They were great beams of wood, sheathed with iron, and often covered by an arrow, and perhaps bomb, proof house, which protected the soldiers while working the ram. Their engineers constructed towers, called, sometimes, *helepoleis*, or city-takers, which, according to Vitruvius, were ninety feet high, in ten stories, and twenty-five feet square at the base, as a minimum; while the largest were a hundred and eighty feet high, in twenty stories, and thirty-four feet square at the bottom. They were mounted on wheels, and from them, when advanced to the spot from which the enemy was to be attacked, engines contrived for the purpose threw stones and other missiles into the city and upon its walls. Machines for throwing arrows and stones were frequently employed, and were often of enormous size and power. Similar engines were built to mount upon their ships, while the vessel itself was converted into an engine of tremendous power by arming its bow with a beak, or "ram," and using the craft precisely as the iron-clad "ram" is employed in modern naval combats. Indeed, the submerged ram now universally adopted for such vessels was the invention of Aristo, the Corinthian, and was itself an improvement upon other forms of ram-bow long before in use.

The ancients were evidently not deficient in ingenuity, in a talent which is the distinguishing characteristic of our time and people; but, in mechanics as in philosophy, their tendency was always toward the consideration of the ideal and the imaginative, rather than toward the useful and directly helpful in practical directions. Philosophers and mechanicians, scholars and artisans, alike, admired the ingenious and speculative, rather than the productive and the practical. They had departed from the primitive ideas of their progenitors, to whom they owed their theology and who had named their gods. They had come to a period in the development of their society which must necessarily result in a cessation of advancement and a stationary era in their civilization.

The age of the dreamer is the period of rest preliminary to stagnation or even retrogression. The ancient civilization, so called, was the culmination of an earlier movement of which history only exhibits to us the later stages, and which was the prelude to a relaxation, in turn the preliminary to another advance. So it happens that the mechanic arts, and their grandest achievements, as illustrated by the engineer of to-day, of the man who, combining intelligence with learning, scientific attainments with the power of practical accomplishment, meets every demand of the age, whether for a railroad or a steamship, a telegraph line or an electric lighting establishment, could no more have been the outcome of ancient ideas and of ancient methods than could the old philosophers have given rise to modern science. The profession of engineering, like that of the physicist or of the chemist, is thus essentially a product of recent phases of civilization. They are all as much the product of the inductive methods as are the sciences themselves. The systematic collection of knowledge, the systematic arrangement of the phenomena and facts of nature into sciences, the systematic promotion and dissemination of learning, modern systematic education, have set the world in motion and with an accelerating velocity; and the modern methods of thought, in all departments of knowledge, of research in all branches of learning, of education, general and liberal, technical and professional, have produced a new heaven and a new earth for mankind.

Thus, as remarked by Professor Youmans:* "In the history of human affairs there is a growing conception of the action of general causes in the production of events, and a corresponding conviction that the part played by individuals has been much exaggerated, and is far less controlling and permanent than has been hitherto supposed. So, also, in the history of science, it is now acknowledged that the progress of discovery is much more independent of the labors of particular persons than has been formerly admitted. Great discoveries belong not so much to individuals as to humanity; they are less inspirations of genius than births of eras. As there has been a definite intellectual progress, thought has necessarily been limited to the subjects successively reached. Many minds have been thus occupied at the same time with similar ideas, and hence the simultaneous discoveries of independent inquirers, of which the history of science is so full."

Writing of the extraordinary importance of the discoveries and researches which, in the nineteenth century, closed this wonderful progress, Dr. Youmans says:

"An eminent authority has remarked that 'these discoveries open a region which promises possessions richer than any hitherto granted to the intellect of man.' Involving, as they do, a revolution of fundamental ideas, their consequences must be as comprehensive as the range of human thought. A principle has been developed of all-pervading application, which brings the diverse and distant branches of knowledge into more intimate and harmonious alliance, and affords a profounder insight into the universal order."

But the consequences of the establishment of the identity of heat and motion, and of the fact that the various forms of energy produced by the various methods of motion of matter, were, if possible, even more important than were the facts just outlined. Once it was perceived that heat and light were forms of motion and energy, it became promptly seen that electricity was also a similar phenomenon, and the question arose whether the vital forces, and all other observed phenomena distinctive of the production of movement and the performance of work, in whatever department of nature, might not be also similarly related, each to all the others. The doctrines of the correlation and of the conservation or resistance of forces and of energies, as these principles have come to be called, were soon seen to be the foundation of all natural science, and to bind all the sciences into one common and closely related system of laws, into a science called by Rankine "Energetics."

(*To be continued.*)

* Correlation of Forces. N. Y., D. Appleton & Co.

THE MATTEAWAN ASYLUM FOR THE CRIMINAL INSANE.

OVERLOOKING the Hudson River at one of the broadest points in its tortuous course, opposite to the city of Newburg, is a public institution erected by the State of New York at an expense of $1,000,000, and of which the public knows little or nothing.

The legal title of the new building, as fixed by the statute, is "The Matteawan Asylum for the Criminal Insane," and it is the only institution for this specific purpose on an extensive scale in the United States.

The contract for building was awarded to Sullivan & Clarke, of Binghamton, N. Y., and the specifications and plans were drawn with studied care by I. G. Perry, the State architect. In April, 1888, ground was broken, and the old De Windt farm lost its identity, as far as nearly two hundred and fifty acres of it, at least, are concerned. Over the very spot where now stand magnificent buildings, Washington, Lafayette and kindred patriotic spirits of the revolution walked, surveyed the magnificent scenery of the Hudson and watched the fortifications upon its many neighboring bluffs.

The new asylum prison towers high on the lofty ridge, presenting from the river the appearance of a monster hotel, as at that distance only the pure Queen Anne architecture of a succession of brick cottages is seen, with peaks, minarets, bay windows, and octagons, the tell-tale bars at each of the windows not being visible to the naked eye. The building is in the form of a parallelogram, with vast hallways extending the entire width, leading into roomy wards and cells, all with high ceilings, an abundance of light and a general air of cheerfulness.

Large intervening open courts on either side of the main buildings are provided for outdoor exercise. The space is ample, but on all sides the inmates are hemmed in by high walls and buildings, a perpetual bar to freedom, and constructed so that escape is as nearly an impossibility as human ingenuity can devise. The external view from the river presents a broken frontage, the large rooms being constructed in circles, semicircles, and octagons, with cathedral glass panels over the big steel-barred windows, much after the style of private residences that are constructed so numerously in this ancient style of architecture. The materials used in the construction are pressed brick, with Potsdam red stone and blue stone trimmings. The basement story is finished in undressed brown stone, the mixture forming a complete and attractive combination. At frequent intervals cupolas and peaks are offset with swells and bays, removing as far as possible the hackneyed style of prisons and asylums and presenting a piece of architectural ornamentation that the most fastidious neighbor cannot decry against.

The main entrance is to what is classified as the administration building, the extreme southern end of the imposing series. Its front is composed of massive Potsdam red-stone columns, undressed and towering up like huge, silent sentinels. The lower portion of the same material forms a *porte cochere*, or wide carriage driveway, which opens into a spacious hall, whence descend mammoth platform stairs so constructed as to give an uninterrupted view of each of the three floors. This building alone is three full stories in height, and is arranged much after a modern, high-toned apartment house in suites of rooms for two families. The trimmings and doors are in hard wood and there is an air of solidity and healthfulness everywhere. The lower floor is divided into offices for the medical superintendent, who will have an instant electrical communication with every keeper, attendant and subordinate in the asylum, quarters for the steward, apothecary, secretary, clerk, and medical staff. The living rooms are finished in cherry and walnut, the dining rooms are decorated with polished yellow pine ceilings, and model store rooms and kitchens are finished similarly.

A doorway leads into a long hall dotted on either side with comfortable rooms for the attendants, and opening by various right angle passages into the six large day rooms set apart for the assembling and recreation of the inmates. Yellow pine floors and polished or metal ceilings shine brightly in the reflections from the large cathedral glass ornamented windows, and to encourage neat toilets, lockers and shelves are provided for hats, coats, and shoes. Adjoining is a large dining room for men and a smaller one for women, while at a convenient distance are two roomy, light and cheerfully furnished and fitted hospital wards. Just above these wards are the dormitories, in which the prisoners will sleep in cots, but timely precaution has been arranged for violent and obstreperous ones in six or more isolated rooms or cells, secured by extra heavy doors. These cells are of hard white walls and excel in completeness most of the "inside" rooms in an ordinary hotel.

Great care has been observed in the construction of this model institution to prevent accident or injury to the crazy inmates. The walls are plastered on wire laths with imported Keene cement, which is hard enough to resist hammer or chisel. The window and door casings are turned, the brick is cast over arches, and there is not a square section to the walls, thus preventing the possibility of any of the convict insane from falling against the sharp edges and inflicting personal injuries. Attached to every ward and dormitory are bath rooms, wash rooms, and well-fitted lavatories, the plumbing being on the lines of the most approved modern sanitary methods.

The buildings are lighted by 1,164 sixteen candle-power incandescent electric lamps, and the grounds are made resplendent at night with ten large arc lights, all of which were constructed and arranged by workmen employed by Thomas A. Edison. The rooms are heated by individual flues set high in the walls, the hot air being furnished from vast cold air flues in the capacious cellars. The stairs are built upon iron rises with slate treads, the outside walls are twenty inches in thickness and in every respect the structure is fireproof. The locks are set in combinations, with a master key which will lock and unlock all of them, precisely the same as are in use in the safe deposit vaults of the great metropolis. Should one of the master keys fall into the hands of a cunning lunatic, the entire combination may be changed and an attempt at a wholesale delivery easily be foiled.

Adjoining the dining rooms, with a long intervening hallway, is the amusement hall. It is fitted up with a large stage and commodious dressing rooms, and will

be furnished with electric footlights, curtain, and scenery. The seats slope down from the rear, and the intention is to furnish plays and concerts for the insane criminals once a week at least, the doctors agreeing that such attractions induce good behavior and become valuable auxiliaries in effecting a cure of slighter mental ailments.

The bars at the windows are made of chrome steel, and like those in use in banks and safe deposit vaults, are warranted to defy file or saw. Accommodations are provided for 500 guests, but on a pinch twice that number of insane can be cared for comfortably.

The kitchen, 40 × 70 feet in dimensions, surrounded by immense bake ovens, steward's pantries, closets, and store rooms, is at the extreme end of the buildings. It is metal roofed, has hard wood doors, with oak and yellow pine casings and a closely knit pine floor. The ceiling is very high, with large openings to drive out smoke and smell.

Passing out at the door and across the grounds a distance of fifty feet, the visitor is led into a heavy brick builing, which contains five boilers, each six feet in diameter and twenty feet long. Adjoining is the dynamo building, and between them towers an immense smokestack of brickwork neatly turned and stone-capped summit. Next to it is a five story water tower, which receives its supply from the village reservoir on the mountains near by, with sufficient force to flood the vast buildings in half an hour. Fire, panic, and loss of life are believed to be an utter impossibility.

The dimensions of this wonderful asylum prison, as furnished to *The World* by the contractors, are:

	Feet.
Main buildings	600 × 54·4
Administration wing	112·6 × 96·6
Amusement hall	46 × 68
Six wards, each	35·8 × 70
Six dormitories, each	35·8 × 70
Kitchen	46 × 54
Male dining room	85 × 54
Female dining room	70 × 15·5
Boiler house	54 × 86
Dynamo building	47 × 84
Water tower	25 × 37

The work of contractors Sullivan & Clarke cost $800,000, exclusive of grading, lighting, heating, and plumbing. The electric light plant, with wiring and lamps, cost $50,000, and the remainder of the $1,000,000 expended by the State was devoted to the purchase of land, preparing it with drainage and plumbing, heating, and furnishing the buildings. Shade and fruit trees will be planted on the grounds, and in a few years it will be one of the garden spots on the Hudson River.—*N. Y. World.*

BAROSCOPIC THERMOMETER.

UP to the present, all thermometers, other than mercurial and alcoholic ones, have generally been based upon the principle of the *deformation* of a body by expansion. The instrument that may be regarded as the type of this kind is Breguet's metallic thermometer.

These apparatus all offer the same inconvenience; after operating a certain length of time, the dilatable body constituting the thermometer undergoes, through successive twistings, certain molecular modifications that change the structure of it, so that the same variation of temperature no longer affects it in the same way that it did at the time that the apparatus was graduated. The readings are therefore no longer accurate, and the effects becoming marked in the long run, the instrument is put out of service.

The object of thermometers of this kind is to obtain the displacement of a movable object (say a needle) capable of being easily seen at a distance, or to establish contacts with determined points. Now, in order that the movable object may be capable of being displaced, it is necessary that it shall be submitted to the action of an initial force, the result of a change of temperature, and such force has generally been sought in the deformations of some substance.

The baroscopic thermometer is designed to overcome such irregularities of operation, through the use of a motive force which, really invariable, always produces the same effects for the same causes.

This force is gravity. In this apparatus there is utilized the weight of the volume to which the body expands; in other words, instead of employing, as an initial force, the breaking of the *geometrical equilibrium* of a body, we utilize the breaking of its *static equilibrium* in assimilating the expansible body to a balance, that is to say, to a lever of the first kind, one of the arms of which is formed of the expansible material, and the other of the expanded part of this same material. It is evident that, with the elevation of the temperature, the second lever arm will increase in weight to the detriment of the first. It will therefore descend, and we shall here have a utilizable force. If care be taken to select for an expansible body a material not subject to molecular variations of structure, it is clear that to a same elevation of temperature there will always correspond a like expansion and therefore a same motive force.

The body employed is mercury, the fluidity of which perfectly adapts it to the construction of the apparatus, and the uniformity of expansion of which secures a perfectly regular operation. Moreover, the great density of this metal gives a great increase of force for a slight increase of temperature.

In principle, the baroscopic thermometer devised by Mr. Debaecker is therefore an ordinary thermometer held in equilibrium by means of a horizontal axis passing through its center of gravity. If the temperature rises, the mercury will expand in the thermometric tube, which will become more weighty and will incline. In case the temperature falls, a contrary effect will follow, and the tube will rise, thus producing an alternating motion capable of being utilized.

The principle upon which the baroscopic thermometer is based being true, it might be constructed of as small dimensions as possible; but what is correct in theory ceases to be so in practice when it is necessary to dispose of an appreciable force in order to render the apparatus sufficiently sensitive and to compensate for the work absorbed by the movement of the parts.

The inventor was therefore led to give the mercurial reservoir quite large dimensions, in order that the weight of the volume expanded might have a value capable of actuating the apparatus. We shall calculate this value further along.

The thermometric reservoir, V, carries a tube, S, of small diameter which terminates in a volution, *a*, whose spirals are so arranged that the whole constitutes a spherical calotte whose center coincides with the axis of rotation of the apparatus. This arrangement was adopted in order to avoid giving the tube too great a length, and also in order that the center of gravity may not be sensibly displaced, whatever be the quantity of mercury contained in the spirals.

The tube, S, is placed in a sort of gutter, Z, of metal, which serves to support it, and which is fixed to a piece of metal, A, that carries the axis formed of the two knives, B, of steel or other hard material, resting upon supports, R, also of steel or other hard material.

The height of the knives is sufficient to allow the

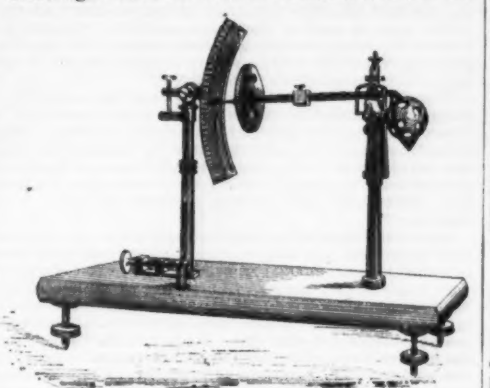


FIG. 1.—DEBAECKER'S BAROSCOPIC THERMOMETER.

horizontal axis of rotation, constituted by the conjunction of the knives and supports, to be situated a little above the center of gravity of the apparatus. A regulating screw, M, placed at the upper part of the piece, A, permits of varying the sensitiveness. In the center of the spherical calotte formed by the spirals there may be fixed either an indicating needle, E, or any movable device capable of producing contacts, if it be desired to use the thermometer for indicating the variations of temperature at a distance. However, the inventor is now putting the last touches on a very complete registering apparatus designed to be actuated by the thermometer.

Calculation of the Thermometric Reservoir, V.—In order to simplify this calculation, we shall take account only of the expansion of the mercury contained in the reservoir, without occupying ourselves with that which is in the small tube, and the expansion of which is practically of no consequence.

Let f be the motive force that it is desired to obtain for a variation of 1° of temperature, and let $\frac{1}{m}$ be the ratio existing between the distances that separate, respectively, the point of suspension of the apparatus from the center of gravity of the reservoir and from the center of gravity of the small tube and its spherical volution constituting the long arm.

If we deduct from the reservoir a weight, p, the effect produced is the same as if there had been added to the long arm a weight $\frac{p}{m}$. On another hand, if we now add to this arm this same weight, p, it will act with

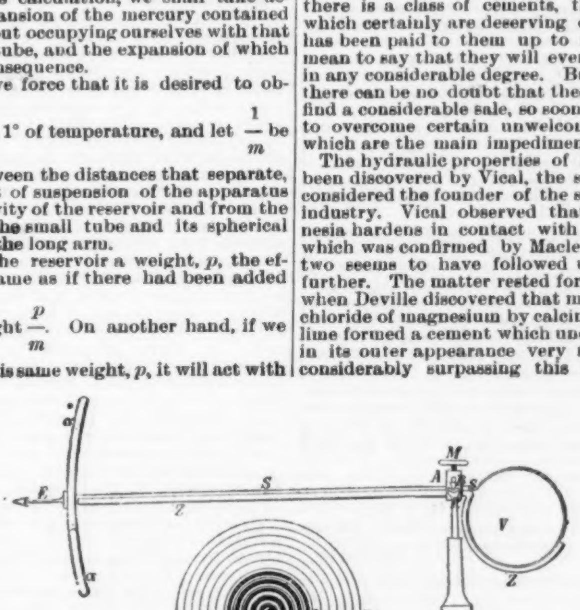


FIG. 2.—DIAGRAM OF BAROSCOPIC THERMOMETER.

a force equal to its own value, and the total effect produced to influence the tube will be equal to

$$p + \frac{p}{m} \qquad (1)$$

We shall therefore have

$f = p\left(1 + \frac{1}{m}\right)$ or $p = \frac{m \cdot f}{m + 1}$ p being the quantity of expanded mercury necessary to cause the apparatus to operate with a force, f. This weight corresponds to a volume $v = \frac{d}{p}$ d being the density of the mercury.

Now, as this quantity v is necessarily the increase of the volume V of the reservoir for 1° of temperature, we shall have

$$v = V \cdot \alpha$$

α being the coefficient of the apparent expansion of the mercury.

We deduce from this:

$$V = \frac{v}{\alpha}$$

and finally

$$V = \frac{m \cdot f}{d \cdot 2\,(m+1)} \qquad (2)$$

It will be seen from formula (1) that the difference of length of the arms is unfavorable in the sense that the weight of the quantity of mercury displaced acts with so much the less force in proportion as the ratio is greater; but this arrangement has been employed in order to render the apparatus lighter, and therefore more sensitive. The maximum effect will be obtained with arms of equal length, for the weight p will then act with a force equal to $2\,p$.

In order to establish the graduations, the formula of the sensitiveness of the balance is taken as a basis — a formula that gives the tangent of the angle described by the beam for a given load.

Instead of a spherical reservoir of wide diameter, the mass of which requires a certain time to take the temperature, it would be possible to adopt a spiral reservoir that would be more sensitive.

Finally, in order to render the apparatus lighter, mercury might be left only in the long arm, and the reservoir might be filled with alcohol, which is very expansible. But this arrangement would diminish the precision of the instrument. Moreover, it has been tried already without much success.—*Le Genie Civil.*

THE PRACTICAL APPLICATION OF MAGNESIA CEMENT.*

By CARL OTTO WEBER, PH.D.

THE name of cement is applied to a certain class of chemical compounds which, when in the form of a fine powder mixed with water, within a certain time form a solid homogeneous mass of stone-like appearance and great hardness. One class of these cements, which we may roughly term alumina-lime silicates, has developed into an industry of the highest importance, producing millions of tons every year, although it is hardly 70 years since the beginning of the manufacture of these products on a large scale. The literature, scientific and technical, of this branch of chemical manufacturing is of extraordinary dimensions, which is, however, not very astonishing, if we consider on the one hand the commercial importance of the article, on the other hand the very great complexity of this matter from a scientific point of view.

There exists, however, besides the silicate of lime cements, a very great variety of other cements, some of which are used in workshops every day, but offering, neither commercially nor scientifically, much to interest us. As competitors with the alumina lime silicates they are altogether out of the question. But there is a class of cements, the magnesia cements, which certainly are deserving of more attention than has been paid to them up to now, although I do not mean to say that they will ever rival ordinary cement in any considerable degree. But on the other hand there can be no doubt that these cements might easily find a considerable sale, so soon as the means are found to overcome certain unwelcome properties of them, which are the main impediment to their use.

The hydraulic properties of magnesium oxide have been discovered by Vical, the same man who may be considered the founder of the silicate of lime cement industry. Vical observed that freshly calcined magnesia hardens in contact with water, an observation which was confirmed by Macleod, but neither of the two seems to have followed up this experiment any further. The matter rested for more than forty years, when Deville discovered that magnesia, obtained from chloride of magnesium by calcination, and carbonate of lime formed a cement which under water sets to a mass in its outer appearance very much like marble, but considerably surpassing this material in hardness. Deville found that the hardness these cements attain depends largely upon the density of the magnesia used.

Magnesia salts precipitated with alkalies yield a magnesia of great hardness, forming cements of a very poor quality, whereas the magnesia obtained from chloride of magnesium by calcination is of great density. To use Deville's method for the production of this cement on a commercial scale is out of the question for economical reasons. But considering the composition of Deville's cement, magnesia and carbonate of lime, it is not surprising that experiments have been made with a view to utilize dolomite, a natural magnesia-lime carbonate, for the manufacture of the product in question.

If dolomite is heated to a temperature below red heat, the carbonic acid of the magnesia carbonate, but not of the lime carbonate, is given off and the resulting product is Deville's cement. On further investigation of this matter, Grace Calvert found that the hydraulic properties of this cement increase with the

* Lately read before the Manchester Section, Society of Chemical Industry.

proportion of magnesia which it contains, and that in strength and durability it is equal to a good average Portland cement. This standard, however, was subsequently contradicted by Erdmenger, who found these dolomite cements very much inferior to the average Portland cements.

The interest which this class of magnesia cement at one time attracted by and by subsided, and to-day the question of dolomite cements has sunk nearly into oblivion. If we take into consideration that dolomite cements could be profitably produced at about two-thirds of the price of Portland cements, it is obvious that their qualities must be of such an unsatisfactory kind as to render them unfit for successful competition with the silicate of lime cements.

At about the same time Deville made his researches on the magnesia lime carbonate cements, Sorel discovered his magnesia cement, which he described as magnesium oxy-chloride. He produced it by forming a paste from a finely ground magnesium oxide and a solution of magnesium chloride from 30 to 70 per cent. strong. This cement, which sets tolerably quickly, forming a very hard mass, considerably harder than marble, gives extraordinary high figures in the crushing test, and possesses a tensile strength equal to nearly one ton per square inch, which is about three or four times the tensile strength of a good Portland cement.

It has the further advantages of being fairly cheap, producing splendid concretes with as much as ten times its own weight of indifferent materials, and having a beautiful white color, so that it appears scarcely doubtful that if magnesia is going to win a place among the important cements, it will be in the form of Sorel's cement or some improvement thereon.

One of the most important items to be observed with magnesia cement is to use a magnesia of great density and as free as possible from carbonic acid. A few per cent. of carbonic acid absorbed by the burnt and powdered magnesia are sufficient to so considerably interfere with its action as to render it absolutely useless. The reason of this is, not that the magnesium carbonate formed, by its chemical properties, prevents the formation of a cement from the unchanged magnesia on the interaction of the solution of chloride of magnesium, but that the magnesium carbonate envelops each particle with a film entirely indifferent against magnesium chloride, and although in the center of each such particle the cementation takes place, that outside film of carbonate prevents the action from particle to particle, *i. e.*, the agglomeration of the whole mass. A few days' exposure of the magnesia to the atmosphere is quite sufficient to make this substance unfit for use.

The magnesium chloride used for Sorel's cement is the ordinary product as it is used largely in textile industries. It is sold in casks, in which it forms a solid block of white color and crystalline texture, containing about 48 per cent. of pure $MgCl_2$. Of this salt Sorel recommends the use of a solution from 30 to 70 per cent. strong, but I found the results obtained are the more satisfactory the stronger the solutions used, and consequently I always use solutions about 80 per cent. strong.

If from magnesia and such an 80 per cent. solution of magnesium chloride a paste is formed, it sets within a few hours to a solid white mass, the hardness of which still increases for some days. The time of setting to a great extent depends upon the temperature and the moisture of the air at the time the experiment is made, high temperature and little moisture considerably accelerating the setting, whereas low temperature and moist atmosphere show a decidedly restraining influence.

The proportions of magnesia and magnesium chloride are of the greatest influence upon the qualities of the cement. I stated before that the cement produced was the harder the stronger the solution of magnesium chloride used, and this fact was already pointed out by Sorel himself. This might seem to imply that the hardness of this cement could be improved by increasing the proportion of magnesium chloride which enters in the composition. But this is not so. The fact is that in working the cement with an 80 per cent. solution of magnesium chloride, the strength of the cement decreases with increasing proportions of the chloride. The following series of experiments show this very clearly:

No.	MgO	$MgCl_2$ 6 aq. 80 Per cent. Sol.	Tensile Strength per Inch Square.
1*	10	6	1,748
2	10	8	1,300
3	10	10	1,150
4	10	12	1,028
5	10	14	860

* Besides the above proportion of magnesia and magnesium chloride ½ part of water was used, as without this the mixture appeared quite dry and had no plasticity.

This shows distinctly enough that a mere increase in the proportion of the magnesium chloride is detrimental to the cement, a fact which becomes still more prominent some time after the experiment, when first hair cracks appear on No. 5 sample, which in due time develop into gaping fissures, owing to a swelling of the cement after setting. Samples 3 and 4 show the same phenomenon, only in a somewhat smaller degree, the amount of swelling being distinctly in proportion to the amount of magnesium chloride the samples contain. Samples 1 and 2 remain perfect for any length of time.

Considering these facts, we must come to the conclusion that if the stronger chloride solution produces stronger cements than a weaker chloride solution, this is not due to the relative increase in magnesium chloride, but to the decrease of the water of the solution. The correctness of this conclusion is borne out by another series of experiments. Sample No. 1 of the previous series showed the highest tensile strength and stability, and to find out the influence of water, or what comes to the same, of solutions of magnesium chloride less than 80 per cent. strong, I added to the various cement mixtures varying quantities of water:

No.	MgO	$MgCl_2$ 6 aq. 80 Per cent. Sol.	Water.	Tensile Strength per Inch Square.
6	10	7	0	1,468
7	10	6	1	1,784
8	10	6	2	780
9	10	6	3	700

Nos. 6 and 7 test were only made to check the correctness of the tests Nos. 1 to 5, and are in perfect accordance with them. Test No. 8 contains the same proportions of magnesia and magnesium chloride as test No. 7, but double the quantity of water, and the result is a cement not half as strong as the latter; and still worse is No. 9 with 3 parts of water, notwithstanding the fact that the quantity of magnesium chloride is the same in each of the three samples. Sample No. 7 never shows any swelling or hair cracks, but the samples No. 8 and No. 9 are in this respect as bad if not worse than samples No. 4 and No. 5.

These results show that the water of the solution of magnesium chloride plays a very important part in these cements, and acts not simply as a solvent. This is further shown by the fact that a solution of magnesium chloride in absolute alcohol does not form any cement with magnesia, no matter how long it is in contact with it, as long as the moisture of the air is excluded.

Sorel considered his cement simply as an oxychloride of magnesium, but this compound, very probably, does not exist at all. All the samples I described contain a very considerable quantity of water, of which only a very small part is given off at 100° C.; and even at 200° C. not more than 70 per cent. of the total water the cement contains is expelled. From this we have to conclude that the setting of Sorel's magnesia cement is one and the same process as the setting of the Portland cements, *i. e.*, assimilation of water, this process of assimilation evidently being facilitated by the presence of magnesium chloride.

According to this, we shall have to describe this cement as hydroxychloride of magnesium. Bender, to my knowledge, was the first to point this out. Bender evidently used a magnesium chloride solution containing about 50 per cent. $MgCl_2$ 6 aq., as the composition answered the formula $MgCl_2 + 5\ MgO + 17\ H_2O$. This cement lost 3 H_2O in the desiccator at ordinary temperature, 9 H_2O at 100° C., 11 H_2O at 180° C. On treating the cement with cold water, it lost $MgCl_2$, and the composition of the remainder answered the formula $MgCl_2 + 9\ MgO + 24\ H_2O$. Boiling water removes the magnesium chloride entirely, resulting in a cement of the formula $2\ MgO,\ 3\ H_2O$, and Bender further adds that neither the treatment with cold nor with hot water has any destructive effect upon the agglomerated cement.

My experiments do not corroborate this statement, nor is it in accordance with the results of the experiments made on a large scale with Sorel's cement. It is perfectly correct that water extracts $MgCl_2$ from the cement, which assimilates a proportionate amount of water, but this reaction invariably destroys the agglomeration of the cement; still more so if boiling water be used. This effect, produced by the action of water, makes Sorel's cement utterly useless for outdoor purposes, where it would be exposed to the influence of atmospheric moisture, and on that score failed all experiments on a large scale. The Union Stone Company in Boston, U. S. A., used Sorel's cement for the manufacture of artificial stones and emery wheels, and, as far as I am aware, the artificial stones were a failure. How the emery wheels turned out is not stated, but I am afraid the results were not very gratifying, as my own experience showed that emery wheels made from Sorel's cement are rather dangerous in use. They may for some time run right enough, and work extremely well, but they suddenly burst without any apparent cause. These very serious drawbacks are sufficient explanation that Sorel's cement, in spite of its cheap price and other advantages, is very little used.

If, instead of the magnesium chloride, a substance could be found which would form an insoluble compound with magnesia and at the same time have the same active properties with regard to the hydration of the magnesia, all these drawbacks would at once cease to exist, and, no doubt, the magnesia cement would forthwith take its place as a cement of the first order, admirably adapted for the manufacture of artificial stones for building, ornamental, and a number of other purposes. Already Sorel hinted that magnesium chloride might be dispensed with and other compounds used instead, but at the same time he did not mention any compound better suited to the purpose than magnesium chloride. I experimented with chloride of potassium and chloride of sodium, both of which act in a similar way as the chloride of magnesium, but certainly with no better results. The chlorides of the alkaline earths do not answer at all, nor do any of the sulphates of the alkalies or alkaline earths. But there is a decided action by silicic acid, or such of the silicates which, being treated with hydrochloric acid, produce gelatinous silicic acid. I experimented with powdered flint, infusorial earth, hydrated silicic acid, and anhydrous silicic acid, the last two named produced from a solution of silicate of soda by addition of hydrochloric acid. The silicates I used were silicate of soda, silicate of magnesia, and silicate of lime. Powdered flint, as will be expected, showed extremely little, if any, action, although it had been most carefully incorporated to the magnesia; the cement it produced took considerable time in setting, and was only moderately strong. Infusorial earth gave considerably better results, the cement setting very quickly and showing considerable hardness and strength. Hydrosilicic acid acted so suddenly that it was past the maximum of its action before it was properly mixed with the magnesia. Precipitated anhydrous silicic acid proved the best of the series, producing after ten hours' setting a very hard and in every respect very strong cement of perfectly white color. Silicate of soda forms with magnesia a paste which very soon hardens, without, however, producing a cement of any remarkable properties. The silicates of magnesia and lime behave very much like the soda silicate, but take a longer time to set than the latter. Of the whole series, the precipitated anhydrous silicic acid showed to best effect, and was further proceeded with. A series of experiments was made to ascertain the best proportion of magnesia and silicic acid:

No.	MgO.	SiO_2.	Time for Setting, in Hours.	Tensile Strength per Inch Square.
10	100	5	32	211
11	100	7	24	313
12	100	10	15	780
13	100	15	14	1,300
14	100	22·5	12	902
15	100	30	19	510

To get reliable results it is necessary to incorporate the silicic acid with the magnesia as carefully as possible, otherwise the repetitions of one and the same test may nearly as widely differ in the figure representing the tensile strength as any two of the above tests differ from each other.

This shows that about 15 per cent. of silicic acid are required to give the best result as regards the strength of the cement. Test No. 14 was quicker in setting, but considerably weaker. But even No. 15, the strongest of the series, remains considerably behind the figures we found for the magnesium chloride cements; but on the other hand, these cements made with silicic acid are perfectly indifferent against water, cold or hot, and under no circumstances begin to swell after setting. But a difficulty in the practical use of these cements would be their very great liability to become inert so very soon after exposure to the atmosphere. Two or three hours' exposure I found quite sufficient to nearly annihilate the hydraulic properties of this cement mixture. This is certainly a very serious drawback, as in practical use it would mean a great deal of waste; but it can be overcome simply by mixing the silica magnesia cement with a solution of magnesium chloride instead of water. The cement thus formed sets in about ten hours, and forms an extremely hard mass, which in strength even surpasses Sorel's cement, without sharing the unwelcome properties of the latter. Water takes up magnesium chloride from this cement as from Sorel's, but no expansion is noticeable. Treatment with cold water is quite sufficient to extract all the magnesium chloride, the place of which in the cement is taken by water hydrating the magnesia.

The admixture of silicic acid with Sorel's magnesia cement makes the latter closely related to the hydraulic mortars as well as the Portland and Roman cement, as the formation of a hydraulic magnesium silicate in that mixture is beyond doubt. On treatment of this new cement, after setting, with hydrochloric acid, it slowly decomposes. The whole of the magnesia and about 30 per cent. of the total silicic acid contained in such a cement are in solution, the rest of the silicic acid appearing in the gelatinous state. The best proportions for the preparation of this new cement I found to be:

100 magnesia.
15 silicic acid.
90 magnesium chloride solution, 80 per cent.

This cement is of a tensile strength equal to 1,788 lb. per inch square, the most important part being the mixing of the magnesia and silicic acid, which must be done as carefully as possible. Absorption of carbonic acid previous to use to the extent of about two per cent. has scarcely any effect upon it; a larger proportion acts in precisely the same manner as in the other magnesia cements, and must be avoided.

The practical application of a magnesia cement free from the defects pointed out above will be very great indeed, owing to its cheapness, remarkably fine color and great agglomerating capacity, many times surpassing that of Portland cement. As far as my personal experience goes, magnesia cement is a material of the first order for the manufacture of artificial stones for ordinary building and ornamental purposes, for the manufacture of emery wheels, and for the production of artificial lithographic stones. Only in the first of these applications named can it be said to enter into competition with Portland cement, the other applications being altogether beyond the scope of the latter. Whether magnesia cement will ever be capable of competing with Portland cement in general concreting work and constructions under water I am hardly able to give an opinion yet, but it may interest you to hear that I employed it successfully for the construction of engine beds, the results also from an economical point of view being highly satisfactory.

The materials which can be utilized for the manufacture of artificial stones from magnesia cement are preferably such containing silica or silicates. Sand, crushed granite, porphyry, glass, Yorkshire and Cheshire sandstones, and the like answering very well. The quantity of cement to be used depends very little on the chemical nature of the filling-up material, but is very considerably influenced by the coarser or finer granulation of the materials used. The strengths such mixtures attain is, however, quite independent of the degree of granulation, as under all circumstances we are able to produce from any of the above filling-up materials with magnesia cement a composition very much stronger than the cement itself. This seems a very remarkable fact, and a few examples may serve to illustrate it. I used in the following series of experiments emery simply because this material is readily obtainable crushed to a number of standard sizes, the grains varying in size from ¼ of an inch (emery No. 6) to $\frac{1}{200}$ of an inch (emery No. 200 or emery flour). The samples were always tested one week after they had been made, as it was found that after this time they gain in four months about five per cent. only in strength.

This series clearly shows the remarkable fact above referred to, *i. e.*, that mixtures of magnesia cement and indifferent mineral materials produce compositions at least as strong as the cement itself, and eventually twice as strong. But this result is subject to certain conditions, the most important of which is that the cement mixture used must be such as to allow each particle of the filling-up material to be got perfectly coated with it, after which the mixture must remain of a rather moist, not dry and sticky, appearance. There are, of course, two ways of arriving at this end, the one being to use a rather thin flowing cement mixture to start

with, or to use a larger quantity of a drier cement mixture. Of these two ways, I found the first to give the better result. The strongest cement mixture I produced is No. 1, viz., 10 parts of magnesia and 6 of magnesium chloride solution; these proportions produce a very dry mixture, and you will see that in combination with emery it yields a composition very much inferior in tensile strength to a similar combination made with No. 3 cement, although the latter in its pure state is very much weaker than No. 1. Experiments Nos. 16, 17, and 18 all contain the same cement mixture, but you see how the strength is increased simply by using larger proportions of it, that is making the combined mixture of cement and emery moister. The importance of this point is still better illustrated by using the finer emery, 24 or 36. You will notice that the 20 per cent. compositions, Nos. 16, 20, and 23, show a great falling off in strength corresponding to the finer granulation of the emery, but in every instance the 40 per cent. compositions, Nos. 18, 22, and 25, show the same strength. By using more than 40 per cent. of the cement mixture no further increase in strength is obtained; on the contrary it begins to decrease, and at about 80 per cent. the combined mixtures show the same strength as the corresponding pure cement. Emery flour, however, forms the exception of the rule, as it reaches its maximum strength with 60 per cent. cement. It never attains the strength we could obtain with coarser material, but on the other hand we reach the mimimum strength, that is the strength of the pure cement, only in using equal parts of cement and emery flour.

Cement No. 1 forming an exceedingly stiff paste, it is quite clear that, although it is about the strongest magnesia cement which can be produced, it will never give satisfactory results in combination with indifferent materials. Of course it might appear that its excessive stickiness by addition of water could be so reduced as to give it the required fluidity, but if you look at experiment No. 28, which represents the strongest compound I could obtain under these conditions, you will see, although it is much stronger than the corresponding experiment No. 19, still it remains considerably behind the strength of the pure cement. This might still be accounted for by deficient fluidity, and no doubt it is; but by adding more water, as in experiment No. 29, you see that the result shows the contrary of an improvement. This is evidently due to the detrimental influence of the water as shown by the experiments 8 and 9, and also by No. 30, which otherwise corresponds to No. 18.

No.	MgO.	$MgCl_2$ 6 aq. 80 per cent. sol.	Water.	Emery 16.	Emery 24.	Emery 36.	Emery flour.	Tensile strength, lb. per inch sq.
16	10	10	......	100	......	......	......	1,100
17	15	15	......	100	......	......	......	1,428
18	20	20	......	100	......	......	......	2,236
19	10	6	......	100	......	......	......	868
20	10	10	......	......	100	......	......	901
21	15	15	......	......	100	......	......	1,541
22	20	20	......	......	100	......	......	2,236
23	10	10	......	......	......	100	......	610
24	15	15	......	......	......	100	......	1,680
25	20	20	......	......	......	100	......	2,230
26	30	30	......	......	......	......	100	1,870
27	50	50	......	......	......	......	100	1,108
28	10	6	1	100	......	......	......	1,208
29	10	6	2	100	......	......	......	940
30	20	20	2	100	......	......	......	1,300

Considering the great strength of compounds of magnesia cement, it will appear that it is very well adapted for the manufacture of emery wheels, and indeed it has been used for this purpose for some time; but such an emery wheel is scarcely safe enough in use, for reasons I pointed out before. If, however, to Sorel's magnesia cement the silica magnesia cement be substituted, the wheels produced are of remarkable toughness, and perhaps as safe as the emery wheels considered the safest of all, namely, those made with India rubber as cohesive matter. The proportion of cement in the magnesia emery wheels ought not to be less than 20 per cent. of the emery; it never exceeds 50 per cent. Of a somewhat similar nature is the use of this cement for the manufacture of millstones. The face of these stones can be made from emery with a backing of crushed flint. Such millstones are in hardness, lasting quality, and general efficiency very much superior to natural stones, especially for the grinding of very hard material. For corn grinding they are not so well adapted, though they are used very extensively for the shelling of rice.

The future of the magnesia cement seems, however, to lie in its application for the manufacture of artificial building stones, as very small percentages of the cement are required to form remarkably strong stones. Nearly any mineral material can be used for this purpose, and especially good results can be obtained with mixtures of sand and not too coarse pebble or gravel. The stones may be colored, or given an ornamental face backed by ordinary material; in this way stones are obtained which at very moderate cost resemble in appearance polished marble or granite. The most important question with regard to these stones is of course whether they will resist the influence of the atmosphere as well as a good natural building stone. As far as artificial stones from Sorel cement are concerned, this question must be answered in the negative; but stones made from the silica of magnesia cement withstood the influence of the atmosphere for over 12 months without showing the slightest sign of deterioration. Among the specimens I brought here to-night you will find some which have been exposed for a considerable period without in any way looking the worse for it.

A few experiments which I made with a view to produce artificial lithographic stones proved very successful, in so far as the stone I obtained behaved in practical use in every respect like the natural lithographic stones from the Bavarian quarries, but did not yield the same number of impressions as the latter. This difficulty, however, I consider not very difficult to overcome, as it merely seems to be a question of the absorbing qualities of the stone. The artificial production of these stones would be a matter of no small commercial importance, as up to now the trade in lithographic stones is monopolized by the Bavarian quarry owners.

[NATURE.]

PHOTOGRAPHIC PERSPECTIVE AND THE USE OF ENLARGEMENT.

IT is not uncommon to hear it remarked that photographs make hills look low, or that they make things look "such a long way off;" and that they do so in a great many cases is perfectly true.

In explanation of the apparent lowness of photographed mountains, I have heard it suggested that the eye judges horizontal and vertical distances by different standards, and this, too, is probably the case; but since there is a horizontal and a vertical in a picture as well as in nature, the eye ought to form similar judgments on both.

The true meaning of the appearances alluded to, though they admit of a most simple explanation, is not as generally understood as might be expected.

The fact is that they depend merely on perspective.

In elementary books on drawing there often appears a diagram in which imaginary threads are supposed to be stretched from every point of an object, through an upright sheet of glass, and to intersect in some point behind it. The trace of these threads on the glass will there form a picture of the object which is in true perspective, when viewed from the intersection of the threads; and if the proper amount of light, shade, and color be supposed to be added, this picture, to the single eye so placed, would be absolutely undistinguishable from the object itself.

But now suppose the eye is not at the place of intersection of the threads, but a certain distance farther off or nearer to the glass. It is evident that the apparent angular magnitude of every object in the picture is altered in the ratio of the distance of the intersection of the threads to the distance of the eye from the glass. But this is exactly what would be the case if, keeping the eye at the intersection of the threads, a new picture were formed on the glass either by altering the size of the real objects in this ratio, or their distance from the glass in the inverse ratio.

For instance, let the objects forming the picture be two towers, one say half a mile off and the other a mile, and suppose that the intersection of the threads is one foot behind the glass; to the eye placed at that distance the towers in the picture will subtend the same angle as they do in reality; but if the eye be moved a foot further from the glass, these angles will be halved, and the same picture will then fall on the retina as would be formed there were the eye one foot from the glass and the towers only half their actual size, or if they were removed to the distances of one mile and two miles respectively.

Thus by viewing the picture from the wrong distance, either the apparent size of the objects represented by it is multiplied by ratio $\frac{\text{true distance}}{\text{wrong distance}}$, or their apparent distances by $\frac{\text{wrong distance}}{\text{true distance}}$.

Putting this in symbols, for the sake of simplicity and brevity, we have, if D = true distance of an object from the point of view, A = its real linear magnitude, F = distance at which the picture must be viewed in order to convey a correct impression of D and A. Then if d and a are the values corresponding to D and A when the picture is seen from the distance f, we have $d = \frac{f}{F}$ D when A is judged correctly; $a = \frac{F}{f}$ A when D is judged correctly. Of course both A and D may be misjudged, but apparent and true distances in sizes are still connected by the relation

$$ad = AD.$$

In a photograph, F is the focal length of the lens with which it was taken, and f the distance at which it is looked at. Thus, if, as is generally the case with all moderate sized pictures, the focal length of the lens is less than the distance one would naturally hold the picture at for convenient view, the inevitable result is either that the apparent distances of the picture are greater than the real ones in the proportion of $\frac{f}{F}$, or that the apparent sizes of the things represented in it are reduced in the proportion $\frac{F}{f}$, or a combination of both these wrong impressions is produced.

Which of these effects or what combination of them is suggested depends much on the nature of the picture itself.

In interiors taken with a wide-angle, short-focused lens, distances are enormously exaggerated, while in landscapes it is generally the sizes of things which seem diminished.

As a rule, it may be said that objects which do not themselves suggest any scale will be made to look small, while those which do, such as men, houses, etc., will appear distant.

When $\frac{F}{f}$ is greater than unity, *i. e.*, when the picture is viewed too near, the reverse of the above effects is seen; and as far as the perspective is concerned, the scene is being viewed through a telescope.

The magnifying power of a telescope is the focal length of the object-glass divided by the focal length of the eye-piece, or, in other words, the distance from the lens at which the image is formed divided by the distance from which it is viewed.

If the focal length of the eye-piece is the same as that of the object-glass, there is no magnification, and in the field of the telescope will be seen an exact reproduction of the natural view.

When, however, by shortening the focal length of the eye-piece, magnification is obtained, foreshortening of all the distances in the ratio $\frac{F}{f}$ naturally takes place. This may be practically illustrated in rather a striking way by looking from a railway bridge along a straight piece of line at an approaching train.

Supposing the train to be traveling at forty miles per hour, if the telescopic power be forty, the apparent rate of approach will be only one mile per hour.

From what has been said, it will be clear that just the same laws apply to photographic pictures (or any pictures in true perspective) as to telescopic images, and that there is only one distance at which they will convey a correct impression to the eye.

This being so, it is evident that any photograph taken with a lens of less than about a foot focal length must exaggerate all the distances, or make objects in the picture look smaller than they should, and the only remedy for this is to enlarge the picture until the right distance to view it from becomes also the convenient distance.

Even if this be done, however, there is still a tendency to view the picture too far off; for few lenses, except those for portraits, embrace an angle so small as to be taken in at a single glance, and people are naturally inclined to stand far enough from a picture to see the whole of it at once.

Still, a proper amount of enlargement offers the best means of making a photograph give a true idea of the scene which it represents; and this is especially true of the small pictures taken by so-called "detective" cameras, having lenses varying from four to six inches in focal length; and it is for this end, and not, in general, to enable more detail to be seen, that the enlarging process is most useful.

Of course, negatives for enlargement must be well enough defined to bear being examined from the focal distance of the lens which took them, or less than this (since detail is lost in the enlarging process), and many which would pass muster well enough when held a foot or more off will be found imperfect when looked at from the lesser distance.

In a subsequent article I will, if the editor permits, enter more fully on the subject of photographic definition and its limits, both as they depend on the nature of the various sensitive films and on the lenses by which the image is formed. A. MALLOCK.

AN INCANDESCENT LAMP FACTORY IN THE NORTHWEST.

By W. FORMAN COLLINS.

AMONG the new and important industries of the Northwest, a section of the country that has had an unprecedented and remarkably rapid growth during the past few years, is the incandescent lamp factory recently started by the Standard Lamp Company, of Appleton, Wisconsin. The new company is strongly backed financially and the field for its operation is very extensive, as evinced by the large volume of business already being done by the new concern, although of comparatively recent organization.

The writer having been cordially invited to inspect the new lamp industry has embodied his observations during a pleasant visit there in the following, which, it is hoped, will prove of interest and possibly instructive to those not versed in the process of incandescent lamp manufacture.

The factory of the company is located on the Fox River, on the lower dam, and comprises three buildings, the largest of which is 150 × 80 and three stories high, the others being somewhat smaller and only two stories in height. In the main building is located the dynamo room, and it is worthy of notice here that this factory is entirely operated by water power, being, probably, the only lamp factory so operated in the country. Five dynamos are employed, two each of 150 volts and 250 lights capacity, of the Mayo pattern, direct current; two of 500 volts and 50 amperes, used for treating purposes; and an alternating current machine of 500 volts and 50 amperes capacity, which is of special design and has been imported from Paris, and used for a special and improved method of treating the 50 volt lamps.

The water at present utilized is 225 h. p., obtained from three Leffel water wheels, which are controlled by a new electrical regulating device, designed by Messrs. A. F. & E. L. Oppermann, the electricians of the company. This apparatus maintains the power constant within a variation of one per cent. under all changes in load and enables the greatest uniformity to be obtained in the product. Another noticeable feature is an Archimedean screw for forcing the mercury into the pumps, dispensing altogether with the vacuum power pump.

The carbonizing room occupies all the remaining portion of the lower floor and is fitted up with specially designed furnaces for the carbonizing of the filaments.

On the next floor is the glass room, in which the glass blowers are at work sealing in lamps and making pumps, etc. The pump room is also on this floor, and at present there are 120 pumps in operation. These are of a specially modified Sprengel type, adapted for obtaining the highest possible vacuum, and having several improvements over the ordinary Sprengel, being designed by Mr. W. H. Sauer, superintendent of the glass department, and whose efforts in this line are well known. The socketing and lamp base department is also on this floor.

The third floor is entirely devoted to the testing room, which is fitted up throughout with the necessary testing apparatus. For this department, Messrs. Queen & Co., of Philadelphia, are now engaged in manufacturing a new pattern photometer of the most delicate sensibility to meet the requirements of the constantly increasing business.

The treating department is provided for in the larger of the two other buildings and occupies both floors. This process is of a secret nature, but as the writer was courteously permitted to inspect this work, he had an opportunity to notice the extreme care and precision with which every portion of the work, down to the most minute details, is carried out, and he can say from practical demonstration that the toughness and homogeneity obtained by this process must necessarily be conducive to long life and high efficiency. Ten sets of treating apparatus are employed in this department and it is remarkable with what dispatch and facility the work is accomplished under this system. The greatest care has been taken to prevent danger from fire, and should one break out it will be met with an efficient system of grenades and portable fire engines.

The other two-story building, referred to above, is

utilized as a warehouse and in it are stored a large stock of globes and raw material employed in an extensive manufacture of incandescent lamps.

It will no doubt be of considerable interest to give some details regarding the manufacture of these lamps which the writer has had the privilege of carefully inspecting, from the raw material to the finished lamp. Commencing with the filament, which is made from a peculiar kind of silk thread expressly manufactured for this purpose, of an exceedingly close texture and of remarkable strength in proportion to its cross section, the process of making a complete lamp is as follows: The silk thread is first subjected to a chemical treatment which destroys entirely the animal matter, leaving a structure of great density and strength, and possessing new properties, not heretofore inherent in the silk, which have the very desirable result of lengthening considerably the life of the filament and expunging those elements which usually cause blackening or discoloration after comparatively short use. This process, as far as the writer knows, is peculiar in its entirety to the standard lamp.

The next operation is to wind the chemically prepared fibers on to blocks of hard gas retort carbon of the shape and form of the intended filaments. This is effected by means of a winding machine which insures an even and equal tension and maintains the fibers evenly distributed upon the carbon block forms. A binding thread is then wound around the blocks and fibers at right angles, thus holding them firmly in place upon the block, after which the bottom ends of the fibers are severed. The whole arrangement is then placed in the carbonizing retort among a number of others of similar character, all being embedded in a carbonaceous compound, and the retort is then placed in a special furnace and maintained at an even white heat which is carefully regulated and maintained for a number of hours.

After this baking process the fibrous filaments are taken from the crucible and removed from the carbon blocks and cut to the requisite length to give the desired resistance for the voltage required. They are now found to possess a very different appearance, having become transformed to a carbonized fiber of a highly homogeneous structure, possessing great hardness and resilience.

At this point it is necessary to digress somewhat and explain the *modus operandi* of preparing the stems in which the filaments are mounted. In the first place, the platinum wires for making connection between the filament inside the globe and the cap or lamp base are cut to the necessary length and their ends are then separately flattened out by means of a press and formed into minute tubes by passing them through a draw plate. The wire is then given to the glass blowers, who bend it into a loop and insert it in a small glass tube which, in the manufacture of these lamps, is of a prepared black glass, which is found to make a closer union with the glass of the globe itself when joined together by fusion than if ordinary white glass is employed.

The small glass tube containing the platinum wires is then heated in the blowpipe flame and the ends of the wires having the small tubes in them are drawn apart, thus changing the stilt or stem from a round tube into a flattened V-shaped form with the wires intimately embedded therein, thus enabling an air-tight joint to be made with the globe.

We can now return to the filament which is mounted in the above described stem by inserting its ends in the tubes of the platinum wire formed to receive them, which are then compressed around the ends of the filament and the junctions electrically welded together, thus forming a perfect mechanical and electrical union between the two. The mounted filament is now subjected to a further electrical treatment peculiar to this lamp, which gives to the filament the remarkable property, claimed for it, of increasing in light-giving properties after the first 100 hours' run, instead of deteriorating, as is often the case.

The mounted filament is now complete and ready for inserting in the globe; but before this can be done, the globe itself must receive some attention. The globes are blown, in the case of the 16 c. p. lamps, and moulded, when required for larger size lamps, in a pear shape having a long neck of a width sufficient to allow of the insertion of the filament. The rounded portion of the globe is, at this stage, perfectly smooth, not having the small excrescence or point seen on the completed lamp. The first thing to do is to "tubulate" the globe, for exhausting, which is accomplished by fusing a straight piece of glass tube about three inches long to the center of the rounded portion of the globe, for the purpose of attaching the lamp to the mercury pump. The globe is now ready to receive the mounted filament. The platinum loop on the mount being first cut, so as to form two ends, the whole is then placed inside the globe, through the neck, which is thereupon heated and melted off at the required length, leaving the stem of the filament sealed to, and in the center of, the neck of the globe. Copper wires are next attached to the platinum ends and the neck of the globe is again heated and the filament pushed down with the aid of the copper wires as far in the globe as desired, thus, so to speak, turning over a portion of the neck into the lamp.

This completes the glass blower's work and the lamp is now given to the pumpers for exhaustion and is placed on the pump by means of the glass tube referred to above, and exhausted till a perfect vacuum is attained. This having been secured, the lamp is sealed off by means of a small blowpipe flame at the point of union of the glass tube and the rounded portion of the globe, leaving the familiar point or tip, above mentioned. All that now remains to do is to test the lamps for candle power and to detect the presence of any fault or defect in the lamp, should it exist, which is done by giving them a three hours' run, after which they are placed in the various kinds of lamp bases for use in sockets of different systems, sorted according to voltage, candle power and style of base, and placed in racks ready for packing and shipment.

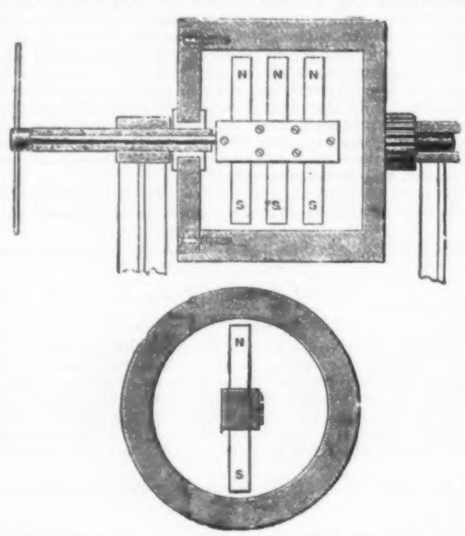
This completes the necessary cycle of arrangements to be gone through in the production of what, when finished, appears to be such a simple piece of apparatus. It is unnecessary to state that throughout these processes the most delicate and painstaking care is taken to prevent the presence of any defect and produce for the market a highly efficient, durable and successful lamp. The whole manufacture of these lamps is conducted under the supervision of Messrs. Oppermann, to whose inventive genius the various special methods and devices used are due.—*Electrical Engineer.*

ON VARIATIONAL ELECTRIC AND MAGNETIC SCREENING.*

By Sir W. THOMSON, P.R.S.

§ 1. A SCREEN of imperfectly conducting material is as thorough in its action, when time enough is allowed it, as is a similar screen of metal. But if it be tried against rapidly varying electrostatic force, its action lags. On account of this lagging, it is easily seen that the screening effect against periodic variations of electrostatic force will be less and less, the greater the frequency of the variation. This is readily illustrated by means of various forms of idiostatic electrometers. Thus, for example, a piece of paper, supported on metal in metallic communication with the movable disk of an attracted disk electrometer, annuls the attraction (or renders it quite insensible) a few seconds of time after a difference of potential is established and kept constant between the attracted disk and the opposed metal plate, if the paper and the air surrounding it are in the ordinary hygrometric condition of our climates. But if the instrument is applied to measure a rapidly alternating difference of potential, with equal differences on the two sides of zero, it gives very little less than the same average force as that found when the paper is removed and all other circumstances kept the same. Probably, with ordinary clean white paper, in ordinary hygrometric conditions, a frequency of alternation of from 50 to 100 per second will more than suffice to render the screening influence of the paper insensible. And a much less frequency will suffice if the atmosphere surrounding the paper is artificially dried. Up to a frequency of millions per second, we may safely say that, the greater the frequency, the more perfect is the annulment of screening by the paper; and this statement holds also if the paper be thoroughly blackened on both sides with ink, although possibly in this condition a greater frequency than 50 to 100 per second might be required for practical annulment of the screening.

§ 2. Now, suppose, instead of attractive force between



two bodies separated by the screen, as our test of electrification, that we have as test a faint spark, after the manner of Hertz. Let two well insulated metal balls, A, B, be placed very nearly in contact, and two much larger balls, E, F, placed beside them, with the shortest distance between E, F sufficient to prevent sparking, and with the lines joining the centers of the two pairs parallel. Let a rapidly alternating difference of potential be produced between E and F, varying, not abruptly, but according, we may suppose, to the simple harmonic law. Two sparks in every period will be observed between A and B. The interposition of a large paper screen between E, F on one side and A, B on the other, in ordinary hygrometric conditions, will absolutely stop these sparks, if the frequency be less than, perhaps, four or five per second. With a frequency of 50 or more a clean white paper screen will make no perceptible difference. If the paper be thoroughly blackened with ink on both sides, a frequency of something more than 50 per second may be necessary, but some moderate frequency of a few hundreds per second will, no doubt, suffice to practically annul the effect of the interposition of the screen. With frequencies up to 1,000 million per second, as in some of Hertz's experiments, screens such as our blackened paper are still perfectly transparent; but if we raise the frequency to 500 million million, the influence to be transmitted is light, and the blackened paper becomes an almost perfect screen.

§ 3. Screening against a varying magnetic force follows an opposite law to screening against varying electrostatic force. For the present, I pass over the case of iron and other bodies possessing magnetic susceptibility, and consider only materials devoid of magnetic susceptibility, but possessing more or less of electric conductivity. However perfect the electric conductivity of the screen may be, it has no screening efficiency against a steady magnetic force. But if the magnetic force varies, currents are induced in the material of the screen which tend to diminish the magnetic force in the air on their remote side from the varying magnet. For simplicity we shall suppose the variations to follow the simple harmonic law. The greater the electric conductivity of the material, the greater is the screening effect for the same frequency of alternation; and the greater the frequency, the greater is the screening effect for the same material. If the screen be of copper, of specific resistance 1,640 sq. cm. per second (or electric diffusivity 130 sq. cm. per second), and with frequency 80 per second, what I have called the "mhoic effective thickness"** is 0·71 of a cm.; and the current intensity at depth $n \times 0{\cdot}71$ cm. from the surface of the screen next the exciting magnet is ε^{-n} of its value at the surface.

Thus (as $\varepsilon^3 = 20{\cdot}09$) the current intensity at depth 2·13 cm. is one twentieth of its surface value. Hence we may expect that a sufficiently large plate of copper of 2¼ cm. thick, or more, will be a little less than perfect in its screening action against an alternating magnetic force of frequency 80 per second.

§ 4. Mr. Willoughby Smith's experiments on "Voltaelectric induction," which he described in his inaugural address to the Society of Telegraph Engineers, of November, 1883, afforded good illustrations of this kind of action with copper, zinc, tin, and lead screens, and with different degrees of frequency of alternation. His results with iron are also very interesting; they showed, as might be expected, comparatively little augmentation of screening effect with augmentation of frequency. This is just what is to be expected from the fact that a broad enough and long enough iron plate exercises a large magnetostatic screening influence; which, with a thick enough plate, will be so nearly complete that comparatively little is left for augmentation of the screening influence by alternations of greater and greater frequency.

§ 5. A copper shell closed around an alternating magnet produces a screening effect which, on the principle of § 3, we may reckon to be little short of perfection if the thickness be 2¼ cm., or more, and the frequency of alternation 80 per second.

§ 6. Suppose, now, the alternation of the magnetic force to be produced by the rotation of a magnet, M, about any axis. First, to find the effect of the rotation, imagine the magnet to be represented by ideal magnetic matter. Let (after the manner of Gauss in his treatment of the secular perturbations of the solar system) the ideal magnetic matter be uniformly distributed over the circles described by its different points. For brevity call I the ideal magnet symmetrical round the axis, which is thus constituted. The magnetic force throughout the space around the rotating magnet will be the same as that due to I, compounded with an alternating force of which the component at any point in the direction of any fixed line varies from zero in the two opposite directions in each period of the rotation. If the copper shell is thick enough, and the angular velocity of the rotation great enough, the alternating component is almost annulled for external space, and only the steady force due to I is allowed to act in the space outside the copper shell.

§ 7. Consider now, in the space outside the copper shell, a point, P, rotating with the magnet, M. It will experience a force simply equal to that due to M when there is no rotation, and when M and P rotate together, P will experience a force gradually altering as the speed of rotation increases, until, when the speed becomes sufficiently great, it becomes sensibly the same as the force due to the symmetrical magnet, I. Now superimpose upon the whole system of the magnet, and the point, P, and the copper shell, a rotation equal and opposite to that of M and P. The statement just made with reference to the magnetic force at P remains unaltered, and we have now a fixed magnet, M, and a point, P, at rest, with reference to it, while the copper shell rotates round the axis around which we first supposed M to rotate.

§ 8. A little piece of apparatus, constructed to illustrate the result experimentally, is submitted to the Royal Society and shown in action. In the copper shell is a cylindric drum, 1·25 cm. thick, closed at its two ends with circular disks 1 cm. thick. The magnet is supported on the inner end of a stiff wire passing through the center of a perforated fixed shaft which passes through a hole in one end of the drum, and serves as one of the bearings; the other bearing is a rotating pivot fixed to the outside of the other end of the drum. The accompanying sections, drawn to a scale of three-fourths full size, explain the arrangement sufficiently. A magnetic needle outside, deflected by the fixed magnet when the drum is at rest, shows a great diminution of the deflection when the drum is set to rotate. If the (compound triple) magnet inside be reversed by aid of the central wire and cross-head shown in the diagram, the magnetometer outside is greatly affected when the copper shell is at rest; it is scarcely affected perceptibly when the copper shell is rotating rapidly.

§ 9. When the copper shell is a figure of revolution, the magnetic force at any point of the space outside or inside is steady, whatever be the speed of rotation; but if the shell be not a figure of revolution, the steady force in the external space observable when the shell is at rest becomes the resultant of the force due to a fixed magnet, intermediate between M and I, compounded with an alternating force, with amplitude of alternation increasing to a maximum, and ultimately diminishing to zero, as the angular velocity is increased without limit.

§ 10. If M be symmetrical, with reference to its northern and southern polarity, on the two sides of a plane through the axis of rotation, I becomes a null magnet, the ideal magnetic matter in every circle of which it is constituted being annulled by equal quantities of positive and negative magnetic matter being laid on it. Thus, when the rotation is sufficiently rapid, the magnetic force is annulled throughout the space external to the shell. The transition from the steady force of M to the final annulment of force, when the copper shell is symmetrical round its axis of rotation, is, through a steadily diminishing force, without alternations. When the shell is not symmetrical round its axis of rotation, the transition to zero is accompanied with alternations as described in § 9.

§ 11. When M is not symmetrical on the two sides of a plane through the axis of rotation, I is not null; and the condition approximated to through external space with increasing speed of rotation is the force due to I, which is an ideal magnet symmetrical round the axis of rotation. Suppose now a second shell inclosing the first to be caused to rotate about an axis precisely through and precisely perpendicular to the axis of rotation of the first shell. The magnetic force at I is by this second shell perfectly annulled through all the space external to it when the rotation is sufficiently rapid. Thus we arrive at the remarkable result that two closed conducting shells, rotating round axes exactly perpendicular to one another through one point,

* Paper read before the Royal Society, April 9, 1891.

** "Collected Papers," Vol. III., Art. cii., § 35.

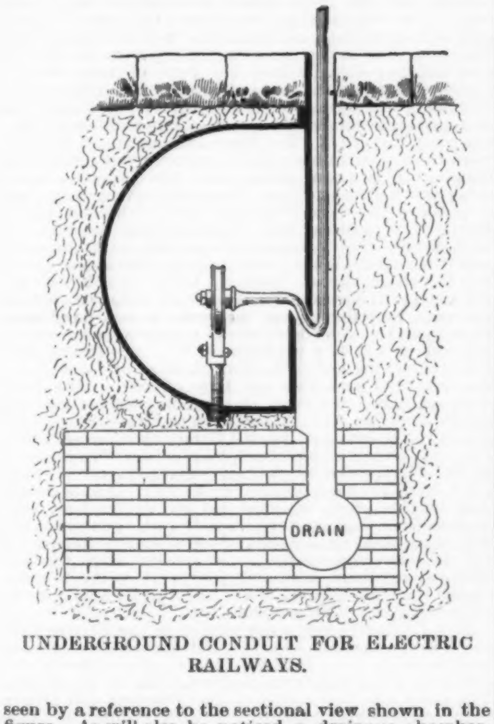
annul for all external space the magnetic force of any magnet whatever held fixed with the inner shell, when the rotation is sufficiently rapid.

§ 12. Instead of the outer shell, an infinite plane disk of metal might be substituted with the same result; and a disk large enough to produce very nearly the same screening effect as if it were infinitely large is arranged for; and an experimental illustration of the result may be shown, by a slight addition to the apparatus before the Royal Society, but there would be no special interest in this illustration. What would really be interesting would be a simple experimental illustration of screening against magnetic force by a rotating disk with a fixed magnet held close to it on one side. A bar magnet held with its magnetic axis bisected perpendicularly by the axis of rotation would have its magnetic force almost perfectly annulled by sufficiently rapid rotation at points in the air as near as may be to it, on the other side of the disk, if the diameter of the disk exceeds considerably the length of the magnet.

UNDERGROUND CONDUIT FOR ELECTRIC RAILWAYS.

PERHAPS the chief objection that has heretofore been urged against the employment of underground conduits for conductors in electric railway systems has been the difficulty in protecting the wires from surface water. Nearly all authorities on electricity are agreed that, at the present time, the conduit system appears to be the most desirable of all, could this difficulty be overcome. With the idea of eliminating this objection Capt. William Bradley, of Fort Wayne, Ind., has invented the form of conduit shown in the accompanying illustration.

The leading idea embodied in the system, and the one on which the principal claim is based, is very simple. It is that of having the opening into the conduit at the side instead of on top. The side plate, which can be easily and quickly removed at any time, projects in the form of a lip over the upward curved portion of the conduit, thus rendering it impossible for water or mud to enter the conduit, as will be readily



UNDERGROUND CONDUIT FOR ELECTRIC RAILWAYS.

seen by a reference to the sectional view shown in the figure. As will also be noticed, a drainage chamber, below the level of the conduit, is provided, from which surface water can easily be carried off by laterals leading to the street sewer. It has been calculated that this drainage chamber can carry away more water than can possibly find its way into it during the heaviest rainfall.

As shown in the figure, the trolley rod is curved in such a manner as to permit its passage under the guard plate and into the conduit, where it supports the trolley wheel on the conductor. The interior of the conduit is to be lined with tarred canvas to prevent the condensation of moisture on the surface of the iron, and the trolley wire is to be supported on insulators of compressed paper.—*Western Electrician.*

THE ELECTRICAL UTILIZATION OF WATER POWER.*

By MADISON BUELL.

THE paper began with an eloquent account of the formation of water in the early days of the world's existence, and showed how at least three-quarters of the surface of the globe are covered with it, part of it being kept in motion by the tides and part through the agency of clouds and springs. These two forces embodied in water, Mr. Buell said, would eventually dispense with the burning of coal for power and crowd the steam engine out of employment. "The energy of the tidal wave, the rapid river, and mighty cataracts transformed into electrical energy is a branch of electrical science that is going to revolutionize the industries of the world."

As to the power represented in the flow of water, Mr. Buell pointed out that not less than 21,446,210 cubic feet pass over the lip of Niagara every minute, while the flowing of nine rivers that empty into the Pacific represents 900,000,000 h. p. every time it descends one foot. On the other hand, the United States has steam engines representing 7,500,000 h. p.; England, 7,000,000; Germany, 4,500,000; France, 3,000,000; and Austria-Hungary, 1,500,000. These figures do not include the 3,000,000 h. p. of 105,000 locomotives. Add this to the other motive power, and it will be found, remarked Mr. Buell, that we have on this globe engines equal to 46,000,000 h. p. These engines do the work of 1,000,000,000 men, or twice the working population of the earth. It is the place of water power utilized electrically to supplement and replace these engines, and it would therefore be worth while to see how far the revolution has already gone.

Mr. Buell with the aid of an imaginary camera then took his audience through a picture gallery of electrical water power plants.

"Let us press the button, and see what the camera reveals. The negative is clear and well defined. The picture is an inspiring one and full of grand significance, to an electrical engineer. It shows that the ethereal vibrations of the sun are melting the Alpine snows, and the water in a never-failing stream is revolving the turbine wheel, which, in its turn, whirls the dynamo armature, and its electrical energy is conveyed miles away over a copper thread to a motor of a woolen manufactory of over 36,000 spindles. Another movement of the ethereal camera, another pressure of the button, and we have another negative, showing hundreds of laborers erecting a large plant at Rheinfelder, on the Rhine, consisting of 20 turbine wheels coupled direct to dynamos of 500,000 watts. The energy is to be transmitted to various industrial centers within a radius of 15 miles.

"Here is one showing a recent achievement in modern engineering, in an electric mountain railway at Burgenstock, near Lucerne, Switzerland. The Burgenstock is almost perpendicular; from the shore of Lake Lucerne it is 1,330 feet, and it is 2,800 feet above the level of the sea. The total length of the road is nearly a mile, operated by two dynamos of 25 h. p., worked by a water wheel of 125 h. p.

"The next negative shows a peculiar view between Pazzala and Lugano, in Italy. At the right of the picture, we see a large waterfall, which supplies the water conducted through iron pipes to the dynamo room, where two Girard turbines of 300 h. p. each run two dynamos, one for continuous and the other for alternating currents, the former working the tramway motors, the latter supplying nearly 2,000 16 c. p. lamps at the hotel and in private buildings. The tramway is a double track one of over a mile in length and is worked by a cable, supported on wooden rollers; one branch of the cable is attached to the ascending, and the other to the descending car.

"Here is a picture of the town of Trente, Austria. A large waterfall furnishes the power sufficient to supply electrical energy to all the mills, hotels, and small industries; it is also furnished to the houses of the poorest inhabitant of the town, not only power, but illumination The next view is an Irish scene of the Giant's Causeway Electric Railway in the north of Ireland, showing two Alcott turbines driving dynamos which furnish power for the motors of the railway; the latter is eight miles long.

"The camera is full of splendid negatives, pictures mostly of electrical plants in Switzerland. Counting them, I find nearly 200 electrical power stations operated by water power, and it would be too tedious to give full descriptions of each one, especially so, when I desire to take hurried views all over the world.

"The next picture represents a hotel, 'The Bernina' at Samaden, Switzerland. It is lighted by electricity, the power being supplied by a waterfall some distance away. As the power is not required during the day for illumination, the current is utilized for cooking, by heating German silver resistance coils. The cooking operations for the hotel are all satisfactorily performed by this method. While I am putting in a new set of plates into the ethereal camera, I will say that it is a well-known fact that Switzerland is disadvantageously situated as a manufacturing country. Although it is supplied with an almost unlimited number of the finest water powers in the world, situated upon unfailing streams, fed by the meltings of Alpine snows, yet these are located in inaccessible valleys and ravines where economical transportation of heavy products is impossible. Railroad lines are in the main valleys at too great a distance from the water powers to render them of much value. Steam power is expensive, as there are no coal mines, and the coal must be brought many hundred miles up heavy grades. This is so costly that the Swiss manufacturers have been unable to compete with those more favorably situated in countries in close proximity to the iron and coal districts. Swiss industries heretofore have been on this account confined to the lighter and more delicate varieties. The recent introduction of methods of transporting and distributing power by electricity is rapidly changing this state of affairs, and in a few years Switzerland will become one of the foremost countries of Europe in all grades of heavy machinery.

"Even on the 'dark continent' the electrical energy sheds its ethereal light, for the first negative is an African view. It is the Forbes Reef Gold Mining Co., of Transvaal, South Africa. The primal source of power is a waterfall three miles from the mine, operating Pelton water wheels coupled direct to Edison dynamos, each dynamo having a capacity of 67 h. p. Over 200 h. p. is transmitted to a distance of four miles. The efficiency of the entire system, from the Pelton wheel pulleys to the mining machine at the distance end, is over 70 per cent. That is, over 70 per cent. of the energy delivered from the water wheel pulleys at the power station is given off at the motor pulleys for work. Another picture in South Africa reveals the fact that the Kimberly mines are also lighted and worked in the same manner.

"Selecting another plate, the scene is changed to Oregon. We have a splendid view of the Falls at Willamette. The energy of the water is here converted into electrical energy, and transmitted a distance of 12 miles to Portland.

"A view in South America shows a cataract of the Juncalillo River, having a fall of 600 feet, supplying water through steel pipes a mile to Juncal station, where it sets in motion ten water wheels, each of 80 h. p., connected to dynamos, the energy of which is used in driving motors for boring through the Andes mountains, to provide for a new railway connecting the Argentine Republic with Chili.

"Now we have a view of Coronado Beach, Cal., where they are endeavoring to utilize the rotary motion of the earth by converting the waves of the ocean into the motive power. The energy is transmitted through a cable, and experiments have demonstrated the entire practicability of the scheme.

"Here is another revelation. It is only one of the many forerunners that augur success to the Niagara scheme. This is a tunnel 16 feet by 12 feet and 2¼ miles long, cut through the mountain from Feather River to Big Bend Tunnel Camp, Butte Co., California. A permanent dam built across the river just below the head of the tunnel diverts the whole stream into the tunnel, and a canal two miles long, extending from the other end of the tunnel, gives a fall of 300 feet, turning powerful Pelton water wheels driving Edison dynamos. The working E. M. F. is 1,000 volts; the conductors are double metallic, and extend 18 miles, delivering electrical energy at 14 points in the circuit, where power is required for winding, pumping, etc. From 10 to 20 Sprague motors, varying from 5 to 50 h. p., are worked by branch conductors from these various stations, the potential varying at the motors from 500 to 700 volts.

"Steam in Nevada is expensive on account of the scarcity of fuel; water is also an expensive commodity, as in this case we see that it is brought from the summit of the Sierras, in pipes, a distance of thirty miles, to the Comstock mines. The Sutro Tunnel at this place affords an outlet for this water 1,700 feet below the surface of the earth. It is the utilization of this pressure that gives an illustration of an amazing exhibition of power. Six of the world-renowned Pelton water wheels are used for running the dynamos in a rocky chamber in the tunnel. From the dynamo room, wires are carried up to the motor room at the top of the shaft, there being a mile in each circuit. The water wheels attached to the dynamos are 40 inches in diameter and run at 900 revolutions. They are made of phosphor-bronze in order to stand the enormous speed the velocity of the water would give them when running without load, which would be 1800 revolutions, giving the periphery of the wheel a speed of 18,864 feet, or more than 3½ miles a minute, the water flowing from the nozzle at a velocity of 19,260 feet a minute. You may get some idea of such force issuing from the nozzle of the pipes, when I state to you that I can see a group of visitors looking at them, with wonder expressed all over their faces, while one of the laborers in the mine wields powerful blows with a sledge hammer upon the stream of water, and the hammer rebounds as though the water were a bar of steel. The compact arrangement of combined dynamos and water wheels, and the noiseless operation of the latter, make it almost impossible to realize the amount of power developed by the swiftly revolving armature.

"In Colorado there is water power enough to furnish light and power for the whole State. The thriving town of 7,000 inhabitants, Aspen, fairly vibrates with ethereal manifestations. Eight Pelton water wheels running 1,000 revolutions, under a head of 820 feet, with a maximum capacity of 194 h. p. each, aggregating some 1,400 h. p., revolve the armatures of as many dynamos, furnishing the current for 120 arc lights of 2,000 c. p. each and 2,000 16 c. p. incandescent lights. These lights are distributed over an area of over four square miles, and are used for lighting the streets of the town, hotels, stores and residences. Greenwood Springs is also in a blaze of electric light. Mills, pumps, hoists and tramways are successfully run miles away from the power station. During the winter months the Pelton wheels, though incased in ice for weeks together, keep spinning away without cessation.

"The next negative gives evidence of the progress of the Japanese people. I can make out five water wheels, having an aggregate capacity of nearly 600 h. p. running dynamos; the electrical energy being transmitted to the city of Kioto, for general manufacturing purposes. The water is conveyed to the wheels through 2,000 feet of sheet iron pipes, and the supply is obtained from the Kioto-Fu-Che canal.

"Views all over California and the Pacific region show the progress already made in the transmission of electrical energy by means of water power. Away up on top of the mountain, nestled in among the clouds, 2,000 feet above Red Cliff, in the very heart of Eagle River Canon, I behold the town of Gilman, more than 11,000 feet above the sea level. Looking across from Gilman on the other side of the great canon, there is a mountain stream called Fall River, rising in the mountain of the Holy Cross, and I can almost hear its roar, as it crashes and tumbles down and over the rocks and enters the Eagle River at the bottom of the canon. This water is brought by a pipe line into the mines, and the fall is equal to 500 feet perpendicular, and its energy drives the dynamos, the electrical energy being conveyed to all parts of the richest mines of gold and silver in Colorado.

"Swinging the camera to the State of Maine, the eye takes in the great Penobscot River, the largest in Maine, draining over 7,400 square miles, a region as large as the State of Massachusetts. For 12 miles from Oldtown to Bangor the river falls over 90 feet, giving several of the finest water powers in the world. At a place called Veazie, which I see is situated four miles above Bangor, there is an electrical plant in the course of construction, which when completed will be one of the largest in the world. Fifteen water wheels of 150 h. p. each will be placed in this plant, so arranged as to run separate or in groups. Six of the wheels are already in operation. The plant will supply lights and power for the cities of Bangor and Brewer. The water power at Veazie is immense; the flow of the river at this point at low water is 146,000 cubic feet per minute, affording 2,500 h. p. with a nine foot head. A portion of this negative shows the town of Dover on the Salmon Falls River, on the division line of the States of Maine and New Hampshire. Light and power are not only furnished to Dover, but to several distant towns. Power is also furnished to a street railway seven miles in length. The water wheel has a capacity of 500 h. p.

"I find to the right of this negative a scene in the Commune of Millas, Western Pyrenees. It shows an area of 1,500 acres devoted to wine vintage. A stream of water furnishes power for lifting and driving purposes, driving dynamos and motors, and furnishing current for 200 incandescent lamps distributed in the houses within the area named. The length of wire used in connecting the various buildings in this system is 63 miles.

* Abstract of a paper read before the Buffalo Electrical Society, April 6, 1891.

"Pointing the camera toward Lake Superior, I see extensive preparations are being made to utilize the waters of that lake, which fall at the Sault about 30 feet to the level of Lake Huron. The water power at Sault Ste. Marie is estimated to have a velocity and volume of 122,000 feet per second, equivalent to 236,000 h. p. A tail race five miles long on the Canadian side and a canal five miles long on the American side are to be constructed. The canals will be each 1,000 feet wide, the widest in the world. Blast furnaces, shipyards, paper mills, pulp mills, flour mills and other industries will all be furnished."

Mr. Buell, then speaking of tidal power, said he saw no good reason why that of the East River between New York and Brooklyn should not be utilized for the two cities. To show how vast is the energy of natural forces, Mr. Buell proposed to consider a storm traveling 60 miles an hour extending over 500 miles of country:

One of our storms exerted a pressure of 30 lb. per square foot, or ¼ lb. per square inch, and traveled at the rate of sixty-six miles per hour. There are in a square mile 27,878,400 square feet, or 4,014,489,000 square inches. If the pressure was half a mile in vertical height, we have for each mile in width of the track of the storm an area of 2,007,244,800 square inches upon which the storm acted with a pressure of ¼ lb. and with a speed of 5,800 feet per minute.

To find the horse power we have the formula:

$$\frac{\text{Area in inches} \times \text{pressure in lb.} \times \text{speed in ft. per min.}}{33,000}$$

The calculation becomes:

$$\frac{2,007,244,800 \text{ square inches} \times \tfrac{1}{4} \text{ lb. pressure} \times 5,800 \text{ feet}}{33,000}$$

The result is 70,557,700 horse power for each mile breadth of the storm.

To produce the same horse power, with improved engines consuming but 2 lb. of coal per hour per horse power, would take 63,000 gross tons of coal.

Assuming the track of the storm to be 500 miles wide, the hourly consumption of coal to generate an equal power would be at least 31,500,000 gross tons, or one and a quarter times the annual product of the entire anthracite coal region.

Coming back to water power, Mr. Buell said:

"Upon the beautiful Spokane River I can see the city of Spokane Falls now one of the prominent cities of the West. In 1885, when the present city was a mere town of a few thousand inhabitants, there was a little wooden shed erected in which there was placed an electrical plant, capable of furnishing electrical energy for twelve arc lights and less than three hundred incandescents. One water wheel furnished the power to run the dynamo and the whole affair had, up to a short time ago, a varied and checkered career. Now consider the contrast. The power I see in Spokane Falls, compared with the water power so far developed in any country, is the peer of them all. As the development proceeds and its immense force made fully available, its financial value will be stupendous; to replace the power which this negative shows, by steam, would constitute the outlay of $10,000 per day for fuel alone. An idea of its actual money value may be obtained when it is stated that the cost of producing one horse power per year by steam is $50, and the lowest total power available at Spokane Falls is 30,000, the amount of wealth annually added to that city on the basis of $50 a horse power per year would be $1,500,000. The power station now seen at the same place where the little wooden shed stood in 1885 is one of the greatest in the world. It is estimated at three thousand horse power and distributes electrical energy for 12,000 incandescent lights and 1,200 arc lights, besides furnishing it for nearly all classes of industries. No city in this country can show for its size so great an employment of electrical energy in everyday life.

"The experiment of transmitting three hundred horse power electrically from Lauffen on the Neckar to the Frankfort exhibition, a distance of over 100 miles, will be tried the coming summer. The result of preliminary experiments already made indicates that the proposed transmission will be a complete success. I have seen an electric arc light produced in Buffalo, where the energy to make such a light came from a point beyond Syracuse, N. Y., over a No. 8 galvanized iron wire, a distance of over a hundred and fifty miles."

Mr. Buell now came to a consideration of the great work proposed at Niagara Falls, and said:

"Let us now take a look at the present hydraulic canal, which even now is considered a work of great importance, though soon to be abandoned. It was constructed in 1855, and is as you see cut through solid rock across the peninsula on which the village is built. The canal is nearly a mile long, and was originally planned to be 100 feet wide and ten feet deep. This canal lay idle for nearly a quarter of a century, until one of our citizens opened up its immense facilities. In 1878 there was only one water wheel on the canal; to-day we see a large number of buildings along the bank of the river using an aggregate of nearly 8,000 h. p. The Brush Electric Light and Power Co. furnish lights not only for Niagara Falls, but for Suspension Bridge. The wires of the company also cross the river into Canada and light Niagara Falls, Ontario, making a circuit of several miles along the bank of the river on each side.

"The idea of the tunnel at Niagara Falls originated with the late Thomas Evershed. The tunnel or tail race is to extend from the surface of the water level below the Falls to a point on the Niagara River above the Falls. It is to be connected with the river by means of short surface canals, wheel pits and cross tunnels. The power expected to be produced by the capacity of the tunnel will be equal to the water power of Lawrence, Lowell, Holyoke, Turner's Falls, Manchester, Bellows Falls, Lewiston, Me., Oswego, Paterson, Augusta, Ga., Minneapolis, Rochester and Lockport combined. The method of using the power is the same as that in operation upon the hydraulic canal. Though the principle is the same, there is a difference in the manner of obtaining the water. At the hydraulic canal there is one long surface canal, a canal basin or reservoir, wheel pits and short tail races to the adjacent high bank of the river. In the case of the tunnel, the Niagara River is the basin or reservoir, directly connected by short surface canals, wheel pits and cross tunnels, with one great tunnel or tail race, nearly two miles in length, which carries the water from the wheels to the Niagara River below the Falls. The tunnel is to be of horseshoe shape, having a capacity equal to a circle of twenty-five feet in diameter, extending through the solid rock from the water level below the Falls to the upper river above the cataract, a distance of one mile. From this point the tunnel is to continue parallel with the shore of the river one and a half miles, at an average depth of 160 feet below ground and about 400 feet from the river, with which it is to be connected by means of surface conduits, through which the water from the river enters and is drawn through the shafts and wheel pits into the great tunnel below. The plans adopted will develop 120,000 horse power. . . .

"Crossing now over the new bridge below the cataract into Ontario, we learn from reliable sources that the scheme for the electrical utilization of the Canadian Falls is well under way. The Pelton Water Wheel Company, of San Francisco, Cal., have sent to the Niagara Falls commission at London, England, an estimate of the wheels and appurtenances for one block of twenty thousand horse power. For an electric section, four wheels to develop 8,000 horse power; for a compressed air section, one wheel of 4,000 horse power; and for the hydraulic or pumping section, two wheels of 4,000 horse power. The scheme, estimates and adaptation of Pelton wheels of such enormous power involved a mass of engineering work creditable alike to all concerned in the labor.

"The Pelton wheel is what is termed a tangential wheel, and is considered of great simplicity of construction and efficiency. The diameter and consequent axial speed of tangential wheels of the Pelton type are such as to adapt them to the requirements in any case, so that direct connection can be made to dynamos, etc. This method has been adopted by the Pelton Water Wheel Company in their plans for the Niagara plant, and the wheels are to suit present or future stipulations of the power company as to speed. The Pelton wheel employs round jets, impinging on peculiarly formed vanes, constituting marked advantages, it is claimed, over wheels of the Girard type. The wheels are not well known in the East, for the reason that the circumstances which led to their use and development in California do not exist elsewhere, *i. e.*, working heads of from 100 to 1,600 feet, and for the reason that every stream is torrential until it reaches the plains. The company furnishing the Pelton wheels claim that they can arrange a system so that a wheel can be made to develop at pleasure 1,000 to 5,000 horse power without impairing its relative efficiency, and that such changes can be made in a moment's time, and when the wheels are in operation. The two plans for the electrical utilization of the water of the Niagara it will be seen are totally different. Mr. Ferranti, the engineer of the power company organized to erect works on the Canadian side of the river, has a preference for the Pelton wheel and is investigating its merits. I am reliably informed that the London commissioners have given a prize premium to the Pelton Co. for their plans in connection with the Norwalk Compressor Co."

GOLD IN COLUMBIA.

To the Editor of the Scientific American:

I send you this article, in regard to the discovery of gold quartz in Cariboo, British Columbia, named the Cariboo Quartz Ledges. And I will give my opinion as to the saving of time and expense, in the discovering of gold quartz in the sections of this country, which I will name, in hopes some of your able correspondents may give their opinions in regard to the discovering of gold quartz ledges.

First, in regard to the discovery of gold, in the streams of Cariboo, British Columbia. On the 8th of May, 1861, a creek was discovered, and named Williams Creek, after one of its discoverers (Dutch Bill).

The prospecting was done about 600 ft. above the lower quartz ledge. The same was discovered some years later crossing this stream.

The prospecting of the 8th of May, 1861, was done down through at least 12 ft. of snow, to the bed of this creek. The prospect being satisfactory, the prospectors located their claims, Dutch Bill having the first choice for locating six hundred feet below where the prospecting was done. This stream, Williams Creek, made a bend to the west ward, then turned again to the north. On the lower part of this bend Dutch Bill located his company's claim of 400 ft. in length and 100 in breadth. In this claim was included one discoverer's claim of 100 ft. in length, and the same in width. The next of choice for locating located above, a company of three, and also included a discovery claim. Above this company, another company of four located 500 ft. in length. In this company was included a discoverer's claim. This last claim, about 400 ft. of its length, was above the bend of this stream mentioned. And at this distance of location, including the first two companies, and 100 ft. of the third company, making 900 ft. in length at this distance, crossed the lower quartz ledge. And above this quartz ledge another was discovered about the same time, crossing this same stream, Williams Creek, at a distance of 2,000 ft. above. Above the third company's location on Williams Creek, these discoverers located three claims for one company. This last location did not include a discovery claim. Some time after others located above the upper quartz ledge. Above the upper quartz ledge the lands widened out; the same below Dutch Bill's location. The first companies located worked their claims by fluming the creek, and washing the gravel through sluices. There being seven companies located below the upper quartz ledge, Dutch Bill company and the company above worked out their claim the first season, which concluded in September, 1861, these two companies sold their fluming material and sluices, also buildings, and abandoned their claims. The company above them resulted. Their first hundred feet proved to be of the same richness as the two companies below. Above this first 100 ft. the rock pitched down above the bend. Just below this pitch of bed rock a company named the Black Jack Company started a tunnel into the mountain, on the east side of the stream, and when the tunnel reached within a line of the rock mentioned which pitched down. Then this company located their mine, commencing at this pitch of rock from third company's location. Below this bend where Dutch Bill had worked out his claims, another company started in another tunnel into the mountain, and the result was, when in line with the Black Jack Company, they struck the lead of gold rich. They struck the lead during the winter of 1862 and 1863.

The Black Jack Tunnel Company struck the lead during the winter of 1861 and 1862. The lower tunnel company, the height of their tunnel above the creek was about ten feet. Another company located 300 ft. below this company, and abandoned the same in 1862.

Another company located below the abandoned claim of 1862. This company worked their claim from a shaft in line south with the other company's location, this company working down their shaft to bed rock, at a distance of thirty feet from the surface, then drifting up toward the abandoned claim of 1862. Their discovery was also made during the winter of 1861 and 1862. The difference of height from the mouth of their shaft and in line with the successful tunnel company below was about thirty feet, making a rise of sixty feet from the lower company's tunnel to the successful shaft company below. The result was, at some time past, part of the mountain from the east had slid to the west, and changed the creek from the pitch of rock above the upper tunnel company's claim to the shaft company's claim, and the consequence was the slide of the mountain had covered the fall of sixty feet with large broken rock.

The first company above the pitch of bed rock stated worked over a supposed bed rock. The same, on walking over, would sink down slightly by the weight of the body, and after rise up again to its natural level. The fourth company above the Black Jack Company's tunnel worked up and over this supposed bed rock, for 60 ft. The top gravel in the bed of the stream, the same averaging about six feet in depth, this top gravel averaging about sixty ounces troy each day. The work of four men shoveling in the sluices on a Wednesday afternoon. This company concluded to go down for the proper bed rock and opened a prospect hole which was about seven feet in diameter. The result was, within 6 ft. struck bed rock, and the result was sixty troy ounces, and the lower gravel resulted to be a blue lead. After this prospect, then went back to the lower part of their claim, and the result was the remainder. The blue lead below produced daily from 200 to 300 troy ozs. per day. About this time of the new discovery a party by the name of Davis was taking notes, and being without a claim, had taken the liberty to measure some company's claims. The result was, this company had 312 ft. Mr. Davis jumped the 12 ft., and went to work with his rocker, washing out the gravel which his 12 ft. claim contained. The proceeds from same resulted in 16,000⅛. This gold having the value of $1,630 at the San Francisco mint, California. Mr. Davis, after jumping this claim, received the name of 12 ft. Davis. The company above this claim jumped, and three others below, and including the Black Jack, and the other tunnel company below, resulted about the same in richness. The first shaft company below the falls resulted in one day's work, from under a large rock, the same being about eighteen inches above the bed rock. The contents of this gravel and the cleaning of the bed rock resulted, after being washed, one hundred and two lbs. troy of gold. The best washing that I saw from one pan of gravel (about six quarts in bulk). This taken from the second company above the Black Jack Tunnel Company resulted 104½ troy ozs., the largest piece of gold having the value of $1,300. There were several other claims below the first shaft company that resulted to be rich. As the lower part of this creek widened out on the surface, and deepened to bed rock, the result was, the remainder was abandoned on account of the difficulty in getting out the water above the upper quartz ledge, the flat widened out there also, and nearly all of the mining claims were abandoned there also, the second season after discovery of this creek.

Now I will give you a description of the discovery of the Cariboo quartz ledges. This taken from article published in your valuable paper. The SCIENTIFIC AMERICAN SUPPLEMENT, March 2, 1878, on page 1799. The same also has a map of the Bonanza and Steadman quartz ledges, Cariboo, British Columbia. The Bonanza ledge was struck at the bottom of the Victoria Gravel Mining Company's shaft. At a depth of 130 ft. the ledge was struck in a drift, and found to be 30 ft. wide.

The ore is a soft quartz, carrying free gold and sulphurets, with a slight trace of silver. This ledge was struck from the Victoria Gravel Mining Company's shaft, which was alongside of the Lowhee Creek, discovered after Williams Creek. A four stamp mill, with imperfect appliances, has been busily engaged in running upon rock from this claim for most of the time since October 8, 1877, with the most satisfactory result. The gross yield for two months to December 1 may be put down at $5,000, the averaging assays from this vein ranging from $14 to $155 to the ton, and average assays across the vein show $33 per ton. The yield from these creeks since 1862 amounts to the astounding sum of $40,000,000. (You can take items from the remainder of this *stated* article published March 2, 1878.) Now will also give you a slight description of the blue lead in California, or Dead River, but now filled up with earthy or rocky matter. The largest dead river is known as the "Big Blue Lead" and has been traced from Little Grizzly, about latitude 39° 45', in Sierra County, to Forest Hill, about latitude 38° 55', in Placer County, a distance of 65 miles. The course is south-southeast, the position about 30 miles west of and parallel with the main divide of the Sierra Nevada. The elevation is 5,000 ft. above the sea at Little Grizzly, and 2,800 at Forest Hill, showing an average fall of 33 ft. per mile. In the whole length of this dead river as traced for a distance of sixty-five miles, assuming that the deposits of gravel average half a mile wide and two hundred feet deep, there were, counting in the portions which have been washed away by the live rivers crossing this dead river, six billion six hundred and sixty million cubic yards of quartz and clay, and the quartz alone must have measured five billion cubic yards. In the live rivers forms only a small portion of the gravel whence came all the quartz of the Big Blue Lead. How did it happen that no granite, slate, porphyry, basalt, or sandstone was buried in this bed? If all the quartz veins now known in California

were cleaned out to a depth of one hundred feet, they would not supply so much as is found in sixty-five miles of a river that must have run for many hundred miles.

The gravel is all water worn, and rounded by long attrition. It came from far north. A piece of rough quartz, while being carried five hundred miles in the fiercest of our mountain streams, would not be worn so smooth as is every pebble in the Blue Lead, and the immense size of the bowlders implies a mighty current. Those in the lowest stratum average in some places a ton, and many are found of twenty tons. These are worn as smooth as the pebbles. They are not found scattered here and there, as though they had tumbled down from the banks of the river near to the spot where they are found. The great river handled these masses of rock with as much apparent ease, and spread them out as evenly as if they had been no larger than pigeons' eggs. But how was it possible that the bed of a large river could be filled three hundred feet deep with gravel? When the miners in 1850, 1851, and 1852 flumed the live rivers of California, and took the gold from their beds, they found a deposit of gravel that did not average more than five feet deep on the bed rock in streams that ran in canons one thousand feet deep, and it is strange that the Big Blue should have filled its bed with gravel. Yet this filling up is not without an analogue in our day. Under the influence of hydraulic washing, Bear River and Yuba River have within the last fifteen years begun to fill up with gravel, and their beds have, for miles, risen seventy feet or more above the levels of 1853. In several cases the blue lead was found by calculation. The miner took his position on a hillside on a line and on a level with other mining camps, and in a few days he found a fortune; and others have spent years working on a similar plan without success. The river must have taken bends on the north side of Rock Creek and Oregon Ravine, and twelve years of searching have not revealed the positions of the bends. But why did the Big Blue Lead die and leave nothing but its gravel and its gold to tell the story of its existence and of its greatness? The main cause must have been the subsequent rise of the Sierra Nevada. Suppose that a range of mountains seven thousand feet high were upheaved thirty miles east of the Mississippi; that the bed of that stream was, on the mountain side, three thousand feet above the sea, and that thirty miles west the country retained its present level, the result would be that the present Mississippi would soon be a dead river; it would be cut across by streams running down the mountain side, and pouring into a new Mississippi thirty miles or more west of the present one.

We know that the Sierra Nevada has been upheaved; that a large stream ran on what is now the mountain side, and that it has been succeeded by a new river farther west, and we must infer that the death of the old and the birth of the new river were caused by the upheaval.

A question suggests itself whether the great dead river was the predecessor of any live stream; but to this no satisfactory answer can now be given, and it is doubtful whether time and research will ever furnish one. The Big Blue was parallel to the Sacramento, and has to a certain extent been succeeded by it, but it drained a much larger district than the Sacramento does, or the rainfall of the country was much greater in the era of its existence. The Sacramento does not carry one-fourth of the water which ran in the Big Blue—probably not one-tenth. If we could ascertain that the quantity of rain had not altered, then we would be justified in presuming that the Columbia river, which would about fill the bed of the Big Blue, instead of turning westward at Walla-Walla, originally continued southward until the lifting up of Shasta and Lassen and the adjacent ridges stopped its course and compelled it to break through the Cascade Range at the Dalles. With our present limited knowledge we are not justified in calling the Big Blue river either the Dead Sacramento or the Dead Columbia. The Dead River, the Big Blue Lead, caused many millions of dollars of gold dust to be taken from live streams that crossed this supposed Dead River, washing across the same and carrying the gold down stream. And take note these many live streams crossing this Dead River did not produce any quartz leads at the bottom of these live streams. These live streams and the Big Blue lead was soon worked out, where the same could be worked properly. You can see on the map of the Bonanza and Steadman quartz ledges, Cariboo, British Columbia, that the Bonanza ledge crossed several streams, including Williams Creek below. And the Steadman quartz ledge crossed Williams Creek above, within a distance of 2,000 feet. These quartz ledges produced the gold which was taken from this creek. The creek did not have a sufficient force of water, neither fall enough to continue wearing down the quartz lead and carry the gold down stream. This and other creeks were soon washed out, and after fifteen years of the discovery of this creek quartz ledges were discovered as stated and the claims located as you can see by your map in THE SCIENTIFIC AMERICAN SUPPLEMENT, No. 113. Here in the Republic of Colombia, in some of the rapid mountain streams, gold is continually found and got by diving to the bottom of the stream. When the streams are low the natives diving place a rock or stone, of nearly fifty pounds weight, on their shoulders to keep them down on the bottom sufficient time to fill their wooden bowls with gravel. Then return to the surface and wash out the same. (This wooden bowl is named *betea*.) Now, where does this gold come from? Gold is and has been found for the past one hundred years in some of these rapid mountain streams. On the banks of these same streams there is now no gold. The same has been taken from the banks years past. Some of these mountain streams could be worked by fluming, as has been done in California and other mining countries. But here, with the native labor, would always make a loss by so doing, as the rises of these streams are very quick, and the sudden rises would wash out the fluming many times during the year. All gold is supposed to come from decayed quartz. After the quartz is decayed, and the gold loosened from the same, this gold is then gradually washed down the streams with the gravel. I will make some statements in regard to quartz that has been discovered in streams in the section southeast from Quibdo. Going up the Atrato river, from Quibdo to the Andaguda river, up the same nearly three days, by canoes poled up the streams by natives, to the stream Sando, the same heading to the northeast in the main range of mountains, between the departments of Antiaque and this department of Cauca. This range of mountains at the head of this stream Sando is at least 12,000 feet above the sea.

Some years past, a short distance up the Sando river (the same emptying in the Andaguda river), a native got a piece of quartz rock containing gold. This piece of quartz was taken from the middle of this stream, about midway up the falls, of eight feet rise, within two hundred feet. This piece of quartz was broken off with a bar under four feet of water, and under a shelving rock. This piece of gold quartz proved to be twenty-five per cent. of gold. A German bought the same from the native. This German as he bought it melted the same over a forge, and only a small loss in weight of gold after melting the same. At this place where the quartz was found, the stream being very rapid, and the banks on either side of the stream where this quartz was found, the banks are at angle of over 45°. On the west bank of this stream, commencing on the Andaguda river, a short distance below the mouth of the Sando river, the mountain rises up to the north and connects with the highest mountain in this section within a distance of three miles. This range then continues to the northeastward to the main range mentioned.

This first range mentioned is named the Dujara mountain, and the first main elevation to the east has the appearance of being flat on its top, and natives that have been up on its top say that its center is lower. And no doubt it is an extinct volcano, as many large rock on all sides of this mountain have the appearance of having been melted at some time. These rocks, at a short distance, have the appearance of copper, and most of these rocks are nearly round, as though they had been soft at some time; and their rolling down the mountain has given them the shape which they retain. Breaking off a piece of this rock, see bright specks of some mineral. This mountain has the appearance of being covered in places with lava. The gold from the sides of same has been washed off years past. About two years past the mountain on both sides of the stream Sando, opposite the place where the gold quartz was discovered, a slide occurred, and now no doubt this stream Sando can be turned on the west side sufficiently to prospect for this quartz in the center of the stream. The gold on the bank of this stream was taken from the west side, the same having the high range. The east side is lower, and no gold having been taken from that side. On the opposite side of this eastern range is another smaller stream, the same emptying in the Andaguda river. Above the mouth of the Sando river, on the west side going up this stream, gold was taken, but none from the east side. This stream is worked out within a distance of a quarter of a mile in Sando river above the first quartz discovered as stated. Another piece was found by diving down and filling the betea with gravel. The result was, after washing the contents, some grains of gold and a piece of quartz weighing thirty castellanoes, and the same, after crushing and washing the quartz, after, resulted seven castellanoes of gold. This gold, at the value of \$250⅔ per castellanoe in the Assay Office, New York, will produce over \$110,000⅔ per ton of this class of quartz. A castellanoe is about 71 grains.

Some distance above, in the same stream at different places, quartz has been found on the bottom of this stream, which resulted the same in quality and richness. This piece of quartz of thirty castellanoes was discovered within the past six months, and where discovered the stream is narrow. And on the east side of this stream is a ridge of rock, and I have no doubt the same consists mostly of granite and some slate. This rock, down in the water at this bend, is perpendicular on that side; and the depth of water straight down from this rock is at least 12 feet in depth at this point. Above this bend to the right the river widens out to at least 60 feet, caused by this ridge of rock. Just above this bluff point of rocks the river is quite shallow, and within six feet of distance the depth of water increases to twelve feet in depth. Here crosses the same ridge of rock. The same does not show on the opposite side of the stream. Only a soft granite rock, which has the appearance of having been burned, and the same has a reddish color; and that side of the stream has also been worked, and the same produced coarse gold. A short distance from the stream a bluff hard rock of granite shows for a short distance. I have my belief that this thirty-castellanoe piece of quartz came off the ridge of rock crossing this stream. This place at one time was filled in with trees that had been felled there within three years past, and the foot of a tail race was just above, and the tailings from the same filled this deep place. Since it has been cleared out by the frequent risings of this stream. The falling of these trees may have broken off this piece of quartz. As the native stated to me, this quartz had not been washed much, neither the edges of same rounded off. The east side of the mountain Dujara, some distance above on this stream, above canoe navigation, on account of its falls, by following a narrow ridge from the river Sando to a narrow flat (going about a quarter of a mile above the falls to this ridge), up it to this flat, and this flat about a third of a mile in length alongside of a small stream, a French woman furnished natives with provisions and tools to work this small stream and its banks. The altitude of this flat above the Sando river, at least 1,000 feet, and this French woman bought hundreds of pounds of gold dust from these natives. And I have no doubt another quartz lead crosses the main stream Sando at this ridge, crossing this stream and passing the opposite mountain to another small stream on the opposite side, this stream emptying in the Andaguda river about two miles above the mouth of Sando river. This stream was also rich with gold on its west bank; nothing on its east bank. On the south side of the Andaguda river, in front of the mouth of the Sando river, is the mouth of another stream. Going up this stream for about a thousand feet, is a mountain; the same continues angling to the Andaguda river in a northwest direction. Below from this lower angle, above to the mouth of the stream mentioned in front of Sando river, the distance being a quarter of a mile at the lower angle, the Andaguda river makes a short bend to the north, and about four hundred feet above this lower angle, and back from the Andaguda river, above high water mark, Mr. Stein, formerly from California, sunk a shaft down to bed rock and struck it rich. He made a contract first to pay the owners of this land 10 per cent. on all the gold taken out. Stein carried away over four hundred pounds of gold dust taken from this mine. Stein was consumptive, and this climate agreed with him; Stein using the native labor, and worked this mine until the Andaguda river broke in on him, as he worked down lower than the river after the river broke in on him and flooded the mine. Then he abandoned the same. This angle of mountain first stated had a part of it some day taken a slide and moved the Andaguda river to the north. The Sando river no doubt helped place most of the gold that Stein got, as the bed rock pitched from the mouth of the Sando river to that side. Stein went back to California and got married there; went to the southern part of California for his health and there died soon after his marriage, and no doubt the wife got the remaining proceeds from this mine.

This mine of Stein has not been worked since he left it, now over twenty-five years, and the quarter part of same has not been worked. Some distance from this mine of Stein, below on the Andaguda river, on the north side in a narrow bend of this river, is a whirl in the stream. Now three years past this river was lower than ever known before, and many improving the opportunity to dive down to the bottom of the deep places, with their wooden bowls, and after filling the same with gravel return to the surface and wash out the same. There were cases of half a pound of gold dust taken at one washing from a wooden bowl of gravel. In this whirl many natives were awaiting their turn to dive down, as this whirl had proved to be rich with gold. One piece of gold in this whirl caused several disputes and quarrels, and it is there yet. This piece being long and wedged in between rocks, so that the native ingenuity did not get to work soon enough to get it out before the rise of water. All accounts in regard to this piece of gold say it has considerable weight. All that saw it said it was long. This is no doubt a narrow quartz ledge, and this ledge comes from the Dujara mountain. There is a very rich quartz ledge owned by a native of this country, Bartolo Chavez, and this person has taken from his mine over sixteen million dollars of value of gold from this mine. The entrance to this mine is closed most of the time with an iron door. The mine is not worked at all times, as the owner of same has no family. In this mine gold has been cut off with chisels. This mine is in the main range of mountains (nearly due east from the mouth of the Sando river), and on its turn to the eastward toward the Cauca river, farther to the eastward from this mine, is the Marmato mine, a quartz gold mine worked by an English company for over fifty years. Also another nearer to the Cauca river east, and the same worked by a German company. The entrance to this mine is near the Cauca river, in this department of Cauca, and the same near the boundary lines with the department of Antiaque.

I give these statements, as I believe that the volcano Dujara vomited out much gold. This gold thrown out from the mouth of this volcano and carried down its side, some carried to the different streams near and some of the same carried down where the streams could not be worked properly; and the gold that remained on the banks near the streams has been found and used. In places on the sides of this mountain some gold remains covered up by the various slides on the mountain sides. The great heat from the volcano caused the gold to melt below, and in places where it has been forced up under streams caused the same to cool off suddenly and remain in the bottom of the streams, especially the long piece in the bottom of the whirl in the Andaguda river; the piece which caused several quarrels. And there remains for some Yankee ingenuity to take it out. Some dry season will bring part of it to the surface. And from various quartz ledges crossing the various streams occasionally a piece of quartz is broken off and the same found by some lucky native. Here in this section where does most of the gold come from, the greater part got by native women diving down to the bottom of the streams with their wooden bowls, filling the same with gravel, and after washing the contents. The question is to see the quartz ledges on the bottom of the streams, and take note of the direction they run. Then after sink shafts on either side of the stream as near as possible to the stream in search of the same. In this section there are no quartz miners. Why should there not be as many quartz mines in Colombia as has resulted in California? California has had over forty years' experience at quartz mining, and a thousand quartz miners there to one here in search of quartz; and I do not believe California has given as many showings of quartz that came from the bottoms of the streams as this section has that I have mentioned; and neither so rich. And I have no doubt the average quartz mines worked in this country are 50 per cent. richer than those in California. A great advantage in this country is the climate, as there is no snow to block the roads, and provisions and materials can be got to the mines cheaper than the same was got to the mines in California at their earliest dates. Take note and see the time that was taken to work out the creeks in British Columbia and California; they were finished within three years. Here in the streams mentioned have worked nearly one hundred years or more. And here yet occasionally pieces of rich quartz are found. These pieces of rich quartz show that the quartz did not come down the stream a long distance, or the same would be worn more and in smaller pieces. In my opinion a great saving of time in discovering quartz can be made by two or more persons prospecting for quartz. First to examine the bottoms of the streams, and if a quartz ledge is seen in the streams, then trace the direction of same to either or both sides of the stream, and afterward sink shafts on either or both sides. I believe this to be much less expense.

Also take note of date of discoveries of the Cariboo quartz ledges: the two mentioned. You may have notes of other discoveries. I have none. As Williams creek proved to have the blue lead, this same section may prove to be the head of the blue lead, and the same lead to the Dead river in California. And also take note, in the Republic of Colombia the quartz ledges extend over more territory than any other known mining country. In the state or department of Antiaque, the greater section of the same has quartz mines opened at no great distance one from the other. This

department of Cauca has several quartz mines opened and working the same the native style; none have the proper machinery for working the same. These mines in this department of Cauca include Bartolo Chavez. The Marmato mine and the German company, and several other quartz mines worked by the natives near the mine of Chavez, have also seen rich gold quartz which came from this main range of mountain to the east of Popayan, the capital of this department of Cauca, and gold has also been taken from the west side of the coast range on the Pacific Ocean. The department of Tolima is known to be rich with quartz mines, and the extension of this main range of mountains to the Republic of Ecuador has quartz also, and many mines opened in Ecuador, and the continuation of same range to Peru and Chili. These mines in this Republic of Colombia and those in the Republic of Ecuador will never be worked properly until a railroad is made to get in the proper machinery to work the same, and Yankee capital and brains to manage them. Then this section named will soon produce a hundred per cent. more gold and silver in a shorter time than all of Uncle Sam's dominions. Until a railroad is made the mining country will remain the same.

EDWIN H. PRINDLE.

Quibdo, Departemento de Cauca,
Republic of Colombia, March 16, 1891.

CALIFORNIA ORANGES.

FIVE or six years ago the oranges of the eastern market came from Florida, Cuba, Messina, and other European countries. The southern Californian production was not a prominent feature, and hardly a factor in trade. To-day the reverse is the case. Thousands of trees in the new Southwest are bending low with the golden fruit, and thousands of gleaming heaps are waiting in the groves to be sorted, wrapped, packed, and shipped to the East, where they will find ready sale.

The picking time is on in southern California, and the fortunate possessor of an orange grove can look upon his possessions from day to day and make a fair estimate of his wealth. The first picking is made about the middle of December in the San Gabriel valley, and from the 1st of January, for a month or so, the gathering continues unabated. A few weeks previous the wholesale shippers go the rounds of the groves. Many of them have arrangements from year to year with the owners, while many producers prefer to make new contracts each season. The agent inspects the grove and offers so much per box or so much for the fruit on the tree, and here the responsibility of the owner ceases. The shipper puts on his pickers, the grower receives his check, and another year is begun.

The picking of the orange in large orange centers, such as the San Gabriel valley, is announced by an addition to the floating population. Gangs of pickers—Mexicans, Chinese, Americans, men and boys—gather from far and near, and the groves are filled with gay laughter and song. Everybody is at work, and if the crop, as it is this year, is large, every one feels cheerful and confident. The orange grove of the imagination is a stretch of trees filled with golden fruit, where one can lie in the soft grass and luxuriate in the sight. The actual grove, while beautiful to the eye, is not a place for lounging, as the ground is or should be kept plowed continually and irrigated often by floods of water. But the trees are attractive; ever green, often showing ripe and green fruit and white blossoms at the same time, they are an enigma.

At Pasadena and all through the southern country the oranges are now being picked. A gang of men under the head of a leader or overseer takes possession of a grove bright and early in the morning, two or three men being appointed to a tree, and the picking begins. Tall stepladders enable the pickers to reach the top branches, and each orange is carefully cut from the tree, as if it is pulled and the skin broken it will soon decay. The pickers wear a bag into which the fruit is dropped, which when filled is handed to the washer or scrubber. The latter, generally a Chinaman, washes the black stain or rust from the fruit, polishing it with a cloth, after which it is passed to the assorter. Sometimes a simple machine is used, a runway, so that the oranges of the same size will all collect together. This accomplished, each orange is wrapped in variously colored paper and placed in the box ready for shipment. A counter keeps tally of the boxes, as sometimes the owner is paid by the box, as well as the picker.

In some groves various machines are used. Thus one patent is a knife on a long pole, which is connected with a canvas tube. The orange cut in this way drops into the chute, and by an arrangement of traps drops from one to another, and finally rolls into a box uninjured. The ordinary method of picking, however, is by hand.

The orange pickers are usually a jolly lot, there being something about the business, apparently, that enlivens the spirits and imparts an air of jollity to the party. The Mexicans and Americans labor in harmony, but an orange-picking team composed of Chinamen and Americans appears to work the reverse. The Chinese picker finds that his ladder gives way without warning, dropping him into the thorny tree or upon the ground. He is bombarded with oranges from unseen quarters, or finds his pigtail fastened to a branch; in other words, as a rule, his life in the orange grove is not as pleasant as it might be. He is strongly suspected by his fellows of working at rates that will not support a white man of family, addicted to taxpaying.

At the orange-picking time the country is a marvel to the Eastener. While standing among the oranges the picker looks away over grove after grove, fields of flowers, acres of golden eschcholtzias, patches of wild daisies, bluebells and yellow violets, and finally his eye rests upon the Sierra Madres, or mother mountains, rising but four or five miles distant, the garden wall of this mountain Hesperides. His nostrils inhale the odor of the orange blossoms, while his eyes greet the snow banks of a vigorous winter. The great peaks are capped with snow and the upland blizzard is raging with unabated fury. From the vantage ground of the orange grove the wind can be seen on Mt. San Antonio whirling aloft the snow in gigantic wraiths, tossing it upward in huge clouds that rise hundreds of feet, to be borne away over the lowland and dissipated. With eyes on this arctic scene the observer can scarce believe the facts, scarce realize that he can by a single glance encompass winter and summer. The orange picker, however, has no time to spend on the æsthetics of the subject; he is picking against time, and an eager East is waiting.

It is difficult to estimate in advance. The crop of 1889 amounted to about 2,200 car loads, each car containing 300 boxes, which means that southern California sent East 500,000 boxes or an orange and a half for every man and woman in the United States. The oranges that are being picked now and shipped as this article is read will fill easily 3,000 ordinary cars. They are marketed in the East at a time when the Florida crop is over, and have to compete with foreign oranges only, such as the Valencias and Sicilian fruit, upon which a heavier duty has been placed to afford the California supply a fair opportunity.

A glance at the hundreds of orange groves in southern California at the present picking will hardly tend to convince the novice that fifteen years ago there were few bearing trees outside the old missions in the country; yet this is a fact. The orange groves of Pasadena, Riverside, and other localities are the result of the last fifteen years' work, and the actual returns tell that it has paid. Many of those who first came to California expecting to make a fortune in oranges failed, but the possessors of these fine groves to-day are the envied ones of the community.

The first oranges in southern California were planted by the old mission fathers, who undoubtedly brought the seed from Spain, whereto it originally was carried from western Arabia by wandering tribes. The orange is a remarkable tree. It flourishes in what is apparently the poorest soil, is always green, ripe fruit will hang upon its limbs for a year, and it is always in fruit or blossom. The tree will bear when 150 or 200 years old, while at Versailles there is a tree known to be over 400 years old, and older still is a famous tree at Nice that is fifty feet high and still bears 6,000 oranges a year. Its exact age is unknown.

The orange craze, as it has been called, is most alluring. The prospect upon the outside is of sitting down and waiting for the agent to come around yearly and buy the crop; yet constant work and attention are necessary. The orange grove requires to be irrigated, plowed, and weeded throughout the year, and so far it is a bagatelle. The chief trouble lies in the various parasites. Two years ago many of the groves of southern California were almost ruined by the white scale. Orange men were in despair, and orchards worth thousands of dollars were literally given up to the destroyer and looked as though flecked with snow. The government sent a commissioner to Australia who discovered a ladybug that proved an enemy to the white scale, and to-day the trees are again in fine condition. But other insect pests, the red and black scale, have to be fought, so that the life of the orange grower is not all smooth sailing.

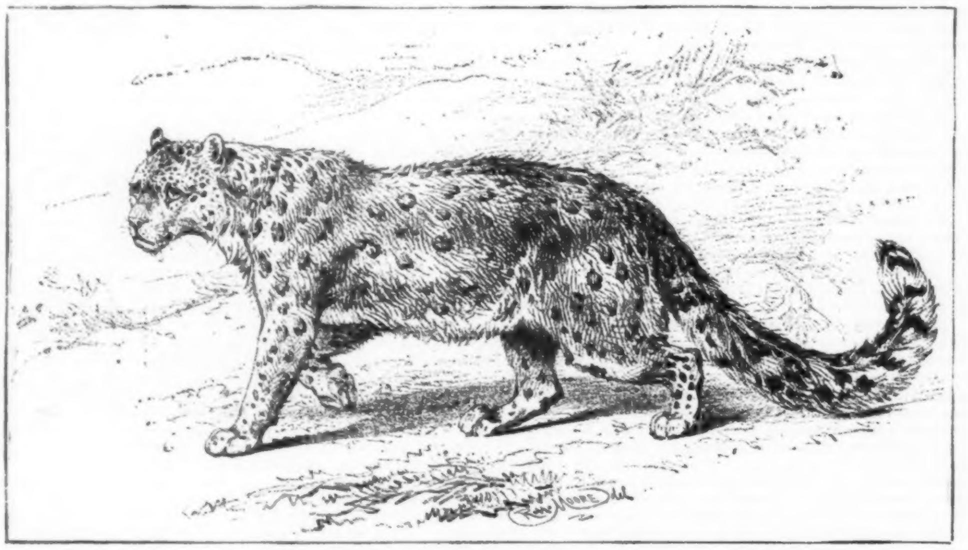
The success of last year and the appearance of the grass of the present season have created an unusual demand for orange land, and thousands of trees have been set out during the past year that will in from four to six years be adding to the productive value of the country. The visitor to California is amazed at the price of land where the orange grows, but his astonishment wears away as the sums received for the luscious fruit are shown. The crop of Riverside may be taken as an instance. Every year nearly $1,000,000 is paid to the orange men alone for their crops. The figures for 1889 were: Citrus fruits (oranges), $630,000; deciduous fruits (dried), $80,000; raisins, $375,000. No wonder land in this vicinity is held high and offered to Eastern farmers, unimproved, at from $300 to $500 an acre. The prices appear extravagant, but it has been demonstrated at Riverside that land will pay for itself in about five years, and in six pay 10 per cent. on a valuation of $4,000 to $5,000 an acre, and in ten years 10 per cent. on a valuation of $10,000 an acre. These are the figures that have fired men's souls, and that are now resulting in the planting of new trees all over southern California.

What especially encourages the grower here is the fact that in the last ten years the consumption of oranges has increased 500 per cent. in this country, and is on the increase. Not only this, but rival and new roads have opened up a market for California fruit which it has not had in former years.

While loads of white boxes are being rolled to the cars for Eastern shipment, we may glance at the various kinds of oranges grown here. First in size and beauty comes the navel, which was imported from Bahia, Brazil, in 1870. It is a large, beautiful fruit, and nearly seedless. Almost equally as large is the Mediterranean sweet, of fine flavor, juicy, with few seeds. While the navels ripen in December and January, the latter orange comes later, often in May or June. The Maltese blood, Rio, paper rind, and St. Michael are popular fruits. The tangerine is what may be termed a fancy variety, very sweet, with a rich reddish-yellow skin, the latter coming off easily. These are the common varieties, but a stroll through Riverside or Pasadena groves will show a score or more, representing all the orange-producing countries in the world. The citrus (or orange and lemon) fair recently closed at Los Angeles was the most successful in the history of this orange country, and so much interest was taken in it that the southern counties of California decided to remove the exhibit to Chicago, and Pasadena ships her exhibit to-day in charge of three of her citizens. As a result Chicago will see the finest display of oranges ever made.—*N. Y. Sun.*

THE OUNCE, OR SNOW LEOPARD.

THE Zoological Society's collection of living animals, London, has just received an important addition in the shape of a young specimen of the ounce, or snow leopard (*Felis uncia*), which has been purchased of Mr. William Jamrach, the well known dealer. The ounce, which is allied to the leopard, but is distinguished by its denser fur, longer tail and lighter color, inhabits the higher districts of Central Asia, and is the only one of the larger feline animals that has hitherto remained unrepresented in our Zoological Gardens. Though many attempts have been made to secure specimens of it from Northern India, none of them have proved successful until the arrival of the present specimen. The ounce has been lodged for the present in a special cage prepared for it outside the lion house, as it was not thought advisable to introduce a denizen of the snowy regions of the Himalayas into the warm atmosphere that so well suits the lions and tigers.—*Ill. London News.*



THE OUNCE, OR SNOW LEOPARD.

REPORT ON INSECTS.

THE history of the following insects, and the methods of destroying or holding them in check, have been worked out by Prof. C. H. Fernald, entomologist of the Hatch Experiment Station of the Massachusetts Agricultural College, Amherst, Mass., or compiled from the most reliable sources. This last has been done because there have been so many demands for information about the common insects as to cause the expenditure of a large amount of time in answering inquiries about them. The following report is from Station Bulletin No. 12, recently published.

THE BUD MOTH.

Tmetocera ocellana (S. V.)

This insect, Fig. 1, is very abundant in some parts of Massachusetts, and has done a vast amount of damage to our fruit trees, much more than has been generally supposed. The minute brownish caterpillars eat out the inside of both leaf and flower buds, and not un-

FIG. 1.

frequently those of grafted scions, and the failure of those grafts has generally been thought to have been caused by imperfect grafting.

These caterpillars make their appearance about half grown in early spring, when the buds of our fruit trees are beginning to swell, and eat their way into the bud, thus destroying it. If one bud does not suffice, they go to a second, and so on.

When a terminal bud is destroyed, the growth is continued from a lateral one; and, as often occurs, the terminal bud of this lateral branch is destroyed by these minute caterpillars, thus giving a peculiar appearance to the older trees of an orchard, so that one can easily recognize the work of the bud moth by the irregular growth of the branches.

The moths emerge during the latter part of June or early in July, and lay their eggs on the leaves of apple and various other trees. The young, as soon as hatched, feed on the leaves, and are about half grown when the

cold weather comes on, and they hibernate in that stage.

To destroy these caterpillars it is desirable to gather all the leaves from under the infested trees in the fall and burn them, and also to shower the trees with one pound of Paris green in one hundred and fifty gallons of water, in the spring when the buds first begin to swell.

This application will also prove valuable for the destruction of tent caterpillars and other early leaf-eating insects.

The following technical account is prepared for those who desire a more complete history of the insect than is given above.

This species was first described briefly by the authors of the Vienna Verzeichniss in 1776, page 130, under the name of *Tortrix ocellana*, and in the supplement of same report, page 318, they state that the larva feeds on hornbeam (*Carpinus betulus*). Fabricius described the moth more fully in his *Mantissa Insectorum*, volume 2, page 228 (1787), and in 1794, in part 2, volume 3, of his *Entomologica Systematica*, page 255, he described the moth again under the name of *Pyralis luscana*. Why he changed the name is not apparent.

Hubner, some time before 1811, in his Sammlung europaischer Schmetterlinge, figured this species on plate 3, figure 16, and gave it the name of *Tortrix comitana*, and in his Geschichte europaischer Schmetterlinge, Tortrices, gives on plate C, Fig. 1, *a*, the larva; and *b*, the pupa, on apple blossoms.

Bechstein, in his Naturgeschichte der schadlichen Forstinseckten, part 3, page 774 (1805), describes the moth and says that it is seen rarely in forests in Germany in the month of June; and that the Vienna Verzeichniss states that the larva feeds on the white beech (*Fagus sylvaticus*), thus making a mistake in the food plant by a misquotation.

Haworth, in his Insecta Britannica, part 3, page 334, published in 1811, adopts Hubner's name and describes six different varieties of the moth, but makes no allusion to the early stages and food plants, which he would have done if he had known them, for, on the title page, he states that all known facts on the early stages are given.

Froelich, in his Enumeratio Tortricum, published in Germany in 1828, describes the moths, but makes no allusion to the early stages.

Treitschke, in Die Schmetterlinge von Europa, volume 8, page 40 (1830), describes this moth under the name of *Penthina ocellana*, and in the supplement, part 3, page 51 (1835), it is stated by Herr Moritz that there are two varieties; one with the middle of the fore wing wholly white, the caterpillar of which lives in *Sorbus aucuparia*. It is pale reddish gray, with black head and thoracic shield. Of the darker variety, the pupæ have been found only on alder, but they probably live on other kinds of trees. In July the moths are frequently found in larch forests.

Stephens, in his illustrations, volume 4, page 92 (1843), describes this moth under the name of *Spilonota comitana*. He states that it is extremely abundant in the vicinity of London, and not uncommon in other parts of the country. The caterpillar feeds on the hornbeam, and the moth appears on the wing about the middle of June.

Duponchel, in the Histoire naturelle des Lepidopteres, tome 6, page 203 (1834), described the moth under the name *Penthina luscana*, and referred to the account of the food plant given in the Vienna Verzeichniss, already mentioned.

Schmidberger, in Kollar's Insects Injurious to Fruit Trees, page 234 (1840), describes this insect under the name of *Tortrix* (*Penthina*) *ocellana*, but gives no description of the larva. He states that the eggs are laid singly on the fruit buds or leaf buds during the month of June [in Austria], and that they do not hatch till the following spring, when the larva reaches its full size in four or five weeks, then pupates and emerges in May as a moth.

Guenee, in his Index Methodicus, page 20 (1845), in a foot note, says the larva is brownish with a black head and shield, and that it lives in the month of May in the topmost leaves of *Alnus*, twisted and drawn together.

Zellar, in Oken's Isis for 1846, describes the full grown larva very briefly, and states that it feeds on oak and alder.

Herrich Shaffer, in his Schmetterlinge von Europa, volume 4, page 234 (1849), says that it is on the wing at the end of June, and that the large light examples are from fruit trees, and that the smaller darker ones are from larch, the larvæ being between the leaves.

Stainton, in his manual of the British Butterflies and Moths, volume 2, page 219 (1359), describes the moth under the name of *Hedya ocellana*, and says the larva is brown, with the head and second segment black, and feeds "on various trees," "very common in the south of England, but scarcer to the north." Wilkinson, in his British Tortrices, published in the same year, describes it under the same name, and says the imago emerges in June and July, frequenting hedges and woods around London; and that the larva feeds on hornbeam, alder, mountain ash and probably on whitethorn. He repeats the description of the larva given by Guenee.

Lederer, 1859, in his Revision of the European Tortricids, page 367, established the generic name *Tmetocera* for this species, because of the notch in the upper side of the base of the antennæ of the male.

Heinemann, in his Tortricina of Germany and Switzerland, page 206 (1863), after describing the moth, states that the larvæ occur in May and June, on fruit and other deciduous trees, and the variety *laricana*, between the needles of larch.

Zeller, in the Entomologische Zeitung for 1873, page 129, describes his variety *laricana*, but gives nothing new of the larva of *Tmetocera ocellana* or of the larva of this variety.

I have two examples of the European variety *laricana* in my collection, but have never seen anything like them taken in this country, nor have I heard that any one here has bred *T. ocellana* larva or any variety of it from larch.

Taschenberg, in his work on entomology for gardeners, published in Bremen in 1874, page 306, says that this species is very abundant everywhere, on the wing from June to August, and further says the caterpillar has sixteen feet, is reddish brown and the head blackish, in early spring upon the buds of different kinds of deciduous trees, and also upon apple and pear trees. In his further account he follows the statement of Schmidberger in Kollar's Insects, given above, and adds a list of five different species of Hymenopterous parasites that prey upon it.

The first account given of it in this country, so far as I can learn, was that by Harris in his Insects Injurious to Vegetation, first edition, page 349 (1841), where he describes it under the name of *Penthina oculana*, but he does not give the early stages.

In 1860, Clemens describes this species in the Proceedings of the Philadelphia Academy of Natural Sciences, page 357, under the name *Hedya pyrifoliana*. His description of the moth and also of the larva is very good, and he says "it inhabits the pear and plum trees."

Since that time many persons have written about it more or less fully, but nothing new has been given on its habits, so far as I have seen, and it has generally been supposed to pass the winter in the egg state. Mr. James Fletcher, in his report for 1885 as Entomologist to the Department of Agriculture of Canada, page 24, writes: "I do not know for certain the life history of this little moth, but believe it passes the winter as a larva on the branches of apple trees, protected by a covering of silk."

For some years past I have observed the habits of this insect, and have been able to carry it through its transformations. The moths emerge between the last of June and the middle of July, though belated specimens are sometimes taken on the wing as late as the middle of August, and one was taken at this place August 25, 1889.

The fore wings expand about three-fifths of an inch. The head, thorax, and basal third of the fore wings, and also the outer edge and fringe, are dark ash gray, the middle of the fore wings is cream white, marked more or less with costal streaks of gray, and in some specimens this part is ashy gray, but little lighter than the base. Just before the anal angle are two short horizontal black dashes followed by a vertical streak of lead blue, and there are three or four similar black dashes before the apex, also followed by a streak of lead blue.

The hind wings above and below and the abdomen are ashy gray. The under side of the fore wings is darker, and has a series of light costal streaks on the outer part.

The moths pair and the female lays her eggs, when in confinement, in clusters of from four to ten or eleven, often overlapping each other. They are oval, flattened, four-fifths of a millimeter long, and half as wide, sordid white, with a narrow border of clear and transparent white, while the center of the egg is one complete mass of minute granules. In about three days the center of the egg has grown darker, and the granules larger; and on either side there is a clear, white, oval space about one-third the length of the egg. In about two days more the outer edge of the center is the same color as in the last stage, and inside this is a narrow, lighter band, while in the center is seen the form of a cylindrical larva larger at one end, and both ends slightly curved toward each other; and in one or two days more the whole form of the larva is visible, the head, thoracic and anal shields being black. The egg stage lasts from eight to eleven days.

When the young larva hatches, it does not eat the shell of its egg, but goes on to the tenderest leaves and almost immediately begins spinning a microscopic layer of silk, under which it eats the outer layer or epidermis of the leaf. The larva is then about three millimeters in length, of a creamy white color, with head, thoracic and anal shields blackish brown, and a few minute pale hairs on the body. The head is very large for the rest of the body. In a week the larva is nearly four millimeters long, light yellowish brown, with the head, thoracic and anal shields dark brown, and it eats minute holes through the leaf, its silken web now being visible to the naked eye. The larva gradually becomes a trifle more brownish, increases in size and enlarges its web along the side of the midrib.

Late in the fall the silken web is quite heavy and thick, and the larva deposits its excrements in little black pellets in the form of a tube, under the web, within which it hibernates during the winter. Not unfrequently two leaves are fastened together by the silk of the web, and sometimes a leaf is secured to a branch of the tree in the same manner.

About the first of May the larva measures seven millimeters when resting, and eight when in motion. It is cylindrical in form, with the head dark brown and of medium size. The body is dark yellowish brown, and the head, thoracic and anal shields very dark, polished brown. There are ten lighter brown protuberances on each segment, from each of which arises one pale hair. On the upper surface of the ninth segment is seen the double undeveloped reproductive organ, of a light brown color. The legs are dark brown and the prolegs yellowish brown. About the first of June the larva is from ten to twelve millimeters in length, and the body has changed to a cinnamon rufous color. From the middle to the last of June it curls or draws together several leaves, which it lines with silk, and in which it transforms to a pupa.

The pupa is seven millimeters long, brownish yellow, tapering from the head to the posterior end, with the wing cases dark brown. There are two rows of dark brown spines pointing backward, across each abdominal segment. The spiracles and anal segment are dark brown. It remains in the pupa stage about two weeks and then the moth emerges.

Some years ago I found a most curious parasite attacking the larva of this species. It was a Hymenopterous insect of a pea green color, and was attached to the top and across the second segment of the larva, on the outside and entirely out of the way of harm, and there it grew fat at the expense of its host, which died a lingering death. The parasite was determined for me by Mr. E. T. Cresson as *Phytodictus vulgaris* Cr.

The following food plants are reported for this country: apple, pear, plum, cherry, laurel oak, and Prof. Harvey informs me that he has bred it from blackberry.

The food plants given in Europe are apple, pear, quince, Carpinus, Crataegus, Sorbus and Quercus.

SPITTLE INSECTS.

The frothy spittle-like masses—called frog-spittle, toad-spittle, snake-spittle, etc.—are formed by small insects belonging to the family Hemiptera or true bugs, and are seen adhering to the twigs and branches of shrubs and trees, and also to the stems of grasses and other plants.

During the early stages of its life, by means of special glands, this insect secretes an albuminous liquid and discharges it from the posterior end of the body, forcing bubbles of air into it after it has been used in respiration, probably. Fig. 2 shows a portion of a

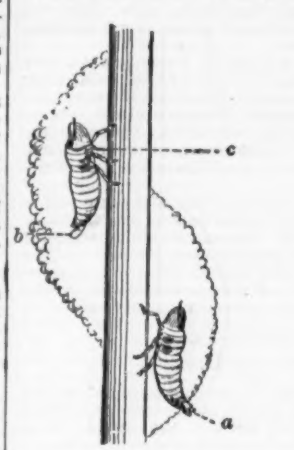


FIG. 2.

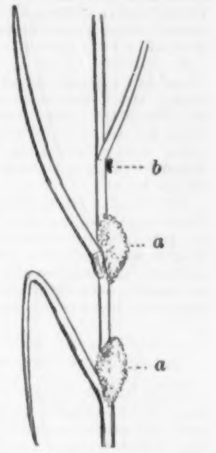


FIG. 3.

grass stem with the young insect in the frothy mass, magnified. At *a*, the insect is shown reaching out the hinder part of the body to secure a bubble of air. At *b*, the insect is allowing the bubble of air to escape in the fluid. At *c*, the mouth parts are shown like a sting piercing the grass. Fig. 3 represents the grass with two masses of froth on it at *a*, *a*, and a young insect exposed at *b*.

These illustrations are from Morse's First Book of Zoölogy, and I am indebted to the publishers of that work for the use of them.

Two different species of spittle-insects are common on grass in Massachusetts, *Philaenus spumarius* (Linn.) and *Philaenus lineatus* (Linn.), and they also occur in Europe, from where they were probably introduced. Although these two insects feed on many different species of plants, it is said that they are strictly attached to grasses and low plants, and that they never occur on trees and shrubs except by accident.

It is not known where they lay their eggs, but as the females are provided with saw-like appendages connected with the ovipositor, it is probable that they cut slits in the stems of the plants near the ground, in which to deposit their eggs. I incline to the impression that they hibernate during the winter in the perfect state, and lay their eggs in early summer. This is true of the allied *Proconia costalis* and *Heliochara communis*, which I have often found fully developed in early spring, just emerging from their winter quarters. The eggs are very large as compared with the size of the insect, and as but very few are laid, these pests are never liable to become excessively abundant. This insect remains in the frothy secretion during the early stages (*nymph*), but, after reaching the adult stage, does not make this secretion, and becomes very active. Although the wings are well developed, it does not fly any great distance, but makes long leaps, and runs quickly, often with a peculiar sideways motion to the opposite side of the plant from the observer.

The spume spittle insect, *Philaenus spumarius*, (Linn.) is very variable in color, about one-fourth of an inch in length, of a clay yellow color, and sprinkled more or less with brown, but some varieties are almost entirely brown. The female of this species lays from eight to ten long whitish eggs.

The lined spittle insect, *Philaenus lineatus* (Linn.) is about one-fourth of an inch long, of an ocher yellow color, with a whitish stripe on the costa or outer edge of the wing covers, and a brownish stripe within and parallel to it. Some of the varieties are dark brown with a whitish costal stripe.

Although the mass of froth on the stems of grass is quite large, it usually contains but a single insect, which is so small that it can injure the plant but very little, and it is very seldom that the pest is abundant enough to make any material difference in the hay crop.

Besides the above named species of Spittle insects in Massachusetts, we have *Clastoptera proteus*, a common species on cranberry and blueberry bushes, *Clastoptera obtusa*, on the leaves and twigs of alder, *Aphrophora parallela*, on the twigs and smaller branches of pine, *A. quadrinota*, and *A. signoreti* on the grapevine, and *A. quadrangularis* on grasses, weeds and blackberry twigs.

THE SQUASH BUG.

Anasa tristis (De Geer).

About the last of June or the first of July, when a few young leaves of the squash have started, the bugs come out of their hiding places, in crevices of walls or fences, where they have passed the winter. The insects pair and the females lay their eggs in little patches on the under sides of the leaves, fastening them to the leaf with a gummy substance. The eggs are

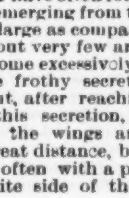


FIG. 4.

rounded oval in form, about one sixteenth of an inch long and about one twenty-fifth of an inch wide, somewhat flattened on the portion attached to the leaf, and of a reddish or resin color.

The young bugs soon emerge, and are slaty gray above with several small black warts on the surface, and there is a greenish tinge to the under surface. As they grow older, they are more of a yellowish green color, with the head slaty black. The young will be found of different sizes all summer, as the female does not lay her whole stock of eggs at one time.

About the last of September, the bugs have attained their full growth, Fig. 4, about three-fifths of an inch long, and are ocher yellow, with so many small punctures that it gives a dusky hue to the body. The full grown bugs when handled, and especially if crushed, give off a very strong odor.

In order to check the ravages of these insects, they should be sought for and killed when about to lay their eggs; but if any have escaped detection, the eggs may be discovered and crushed. Water drained from a barn yard is a good remedy, as it tends to promote the vigor and luxuriance of the plants, thus rendering them less liable to suffer as much from the punctures of the bug

The plants should be visited daily and searched, as the bugs remain quiet in the daytime on the stems, or on the ground under the leaves. Shingles, strips of board or other similar objects may be laid on the ground for the bugs to hide under, when they may be captured and destroyed. Experiments with kerosene emulsion have not thus far proved very successful.

THE PEA WEEVIL.

Bruchus pisi (Linn.)

This insect, Fig. 5, natural size, enlarged at *a*, and an infested pea at *b*, is a native of this country, but is now common to nearly all parts of the world. It is easily distinguished from the other species of its family

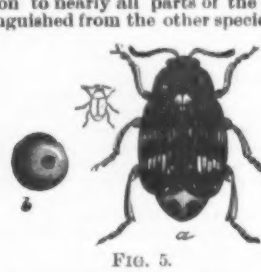


FIG. 5.

by having a depressed head, a very short snout and the antennæ eleven jointed, straight and slightly thickened at the end. On the tip of the abdomen, which is somewhat longer than the wing covers, are two oval black spots, which cause the remaining white portion to look something like a letter T.

It is about one-fifth of an inch long, of a rusty black color, with more less white on the wing covers, and a distinct white spot on the hinder part of the thorax.

The beetles begin to appear as soon as the peas are in blossom, and when the young pods form, the females lay their eggs on the outside of them, and as soon as the eggs hatch, the larvæ, or grubs—which are of a deep yellow color and have a black head—make their way through the pods and into the nearest peas. Only one grub can be fully developed in each pea, and this one will not destroy the germ, for peas will grow if they are infested, but the plant will be feeble, and the weevils will increase rapidly.

After the grubs are fully grown, they eat a circular hole out to the shell of the pea, and then complete their transformations. Some of the beetles emerge from the peas in the fall of the same year that they were hatched, if the summer has been long and hot; but as a general rule they remain in the peas during the winter, and do not issue till the new vines are growing.

The weevils can be killed by taking the peas that are to be kept for seed, and inclosing them in tight vessels with camphor; also by keeping the peas two years, taking care that the beetles do not escape. A good plan is to tie the peas in tight bags and hang them in an airy place till Christmas, and then in order that they may not become too dry, put them in tighter vessels. The best way is to plant only sound peas.

THE BEAN WEEVIL.

Bruchus obsoletus (Say).

The general color of this weevil, Fig. 6, natural size, and enlarged at *a*, is tawny gray marked more or less with dull yellow, and it is less than a fourth of an inch long. Sometimes over a dozen are found in a single bean, Fig. 6, *b*. The female lays her eggs on the out-

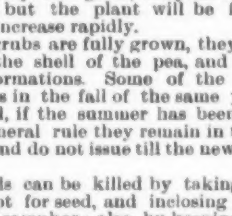


FIG. 6.

side of the young pods, and as soon as they hatch, the young larvæ, or grubs, bore through the pods and into the beans. They rarely injure the germ, and the beans will doubtless grow when only a few occur in a bean; but when the substance of the bean is destroyed, even though the germ is not touched, the bean either will not grow, or will produce only a feeble plant.

Before the larvæ are transformed into beetles, they cut a circular hole out to the shell of the bean and can be easily seen in white or light colored beans, after the final changes. Some of the beetles emerge in the fall, and the remainder in the spring; therefore the beans intended for seed should be tightly tied up in stout paper bags, so that the beetles cannot escape, and kept over till the second year, when they will all be dead. It is better, however, to plant sound seeds only, and destroy all that contain the weevils.

THE MAY BEETLE.

Lachnosterna fusca (Frohl).

This insect, Fig. 7, 1, pupa; 2, larva; 3 and 4, the beetle, is commonly known as the May beetle, June beetle, dor bug, etc., and is very common, making its appearance early in May or June. The body is oblong, oval, and from three-fourths to an inch in length, about one-half an inch in diameter, and of a dark chestnut brown color, while the head and thorax are

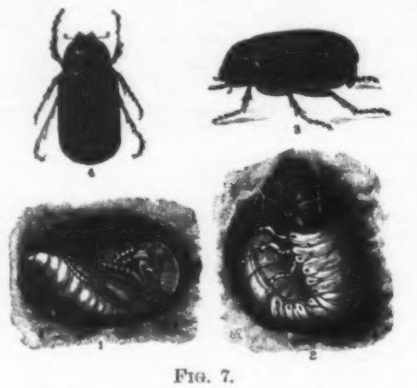


FIG. 7.

sometimes almost black, and the breast is covered with pale yellow hairs. These beetles remain at rest during the day and eat at night, feeding upon the fruit and leaves of different trees, often doing much damage. After living for about three weeks the female lays her eggs and then dies.

The eggs, from forty to fifty in number, are deposited among the roots of the grass in a ball of earth. They hatch in the course of a month, and the young larvæ, or grubs, feed upon the rootlets of various plants. They are soft and white, with a horny head of a brownish color, and have six legs. When cold weather approaches, they burrow deeply in the ground and remain till spring. The grubs do not reach their full size till the third year, when they are about the size of a man's little finger. They rest on one side, slightly curved, and near the hinder end the contents of the digestive system are visible. They then construct an oval shaped cocoon, in which they change into pupæ.

In the spring the perfect insects emerge, live about three weeks and then die. In the grub state they are very injurious to lawns, grass lands and meadows, eating the roots of the grass and causing it to turn brown and die. They are also injurious to strawberries, eating the roots and destroying the plants.

On account of the underground life of the larvæ, or grubs, of these beetles, they are hard to destroy. They have their natural enemies, but these are not sufficient, and other means must be employed to get rid of them. Various animals, shrews, moles and others that burrow, destroy many. Certain birds, robins, crows, blue-jays, black-birds, etc., also eat them, and the tiger beetles kill them. There is also a white fungus which sometimes grows in two long processes from the grubs, one on each side of the head, which destroys them.

Various artificial remedies have been suggested, as the mixing of wood ashes with the soil, which makes it very unpleasant for the grubs, and in some cases has proved very efficient. Shaking the beetles from the trees on to sheets and then burning them is recommended. This can be done best early in the morning. Late fall plowing has also been recommended, but to reach the grubs it must be deep, for they burrow down a considerable depth in order to pass the winter. Swine and dometic fowls are fond of the grubs, and will destroy them when allowed to have access to the infested field.

From experiments made by Mr. W. B. Alwood, it is probable that kerosene emulsion may be used successfully for the destruction of this insect while in the ground, but it is necessary to thoroughly drench the ground, for the purpose of reaching the grubs. This plan is well worth a trial on lawns, but it is doubtful if it would pay in fields.

THE PLUM CURCULIO.

Conotrachelus nenuphar (Herbst).

The plum curculio belongs to the group of snout beetles or weevils, and is very injurious to cherry, quince, peach and apple trees, as well as plum trees. The perfect beetle, Fig. 8, *c*, is about one-fifth of an

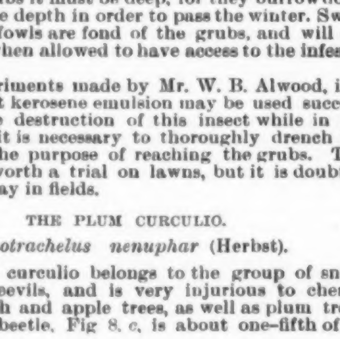


FIG. 8.

inch long, grayish-brown or black in color, while on the wing covers is a black shining hump behind which is a dull yellow band and a few white markings. The thorax and wing covers are roughened and uneven, and the snout is about as long as the thorax.

There is only one brood in a year. The beetles pass the winter in the perfect state, hiding under the loose bark of trees, rubbish and in other convenient places; and are first seen in May or June, when the fruit is fairly set. The female at once lays her eggs, from fifty to a hundred in number, in the young fruit, making a small hole with her snout and depositing only one egg in a single plum. She then cuts a crescent shaped slit in front of the hole, Fig. 8, *d*, thus undermining the egg and preventing the growing fruit from crushing it. The eggs are of an oblong-oval form, pearly white, and can be plainly seen with the naked eye. If the weather is warm, the eggs will hatch in three or four days, but if cold and rainy, they will remain sometimes over a week before hatching.

The young larvæ, or grubs, Fig. 8, *a*, are small, white and footless, and as soon as hatched eat their way to the center of the fruit, causing it to fall before it is ripe. The grubs are fully grown in from three to five weeks, being about two-fifths of an inch long, with a brownish head and a yellowish white body, with a pale line on each side, and a few minute black bristles. They now leave the fruit, burrow into the ground, pass into the pupa state, Fig. 8, *b*, and in six weeks emerge as perfect beetles. These insects are natives of this country, and when first discovered fed on wild plums, and are now sometimes found upon them. As the insect feigns death when disturbed, by jarring the trees under which a sheet has been spread, a great many may be captured and destroyed. It has been recommended to allow poultry to run under the trees, as they will eat the grubs and beetles, and thus hold them in check. It has also been recommended by some to shower the trees with Paris green in water as soon as the fruit is fairly set, and before the eggs are laid, so that the beetles in feeding on the leaves may be destroyed. Others claim that this is of no value, but my experiments thus far have not settled the point either way.

(To be continued.)

VAN 'T HOFF'S LAW OF OSMOTIC PRESSURE.

By D. J. CARNEGIE.

THERE are few, I think, who would oppose the application of the qualification "epoch making" to the recent work of Van 't Hoff in connection with the osmotic pressures of dilute solutions.

Although this work involves nothing of what is popularly styled scientific romance, and is of too specialized a nature to beget the general interest of the public, yet it must be admitted that, taken along with its immediate consequences, it appeared at first sight very much in the light of romance to the smaller world of scientists, whose thoughts and energies it has, notwithstanding, rolled into altogether new courses.

Before detailing this work, however, certain preliminaries are necessary to the full appreciation of the position it assumes in the province of knowledge to which it essentially belongs.

Matter exists in three states: solid, liquid, and gaseous. Up till quite recent times theoretical chemistry has had chiefly to do with matter in its gaseous condition. The deportment of gaseous matter is conditioned by very simple laws, the chief of these being (1) Boyle's law, (2) Charles' law (Gay Lussac's law), (3) Avogadro's law, and (4) Graham's law.

In his "defense of the doctrine touching the weight and spring of the air" (1662) Boyle very quaintly describes how, by means of "a tube crooked at the bottom through the instrumentality of a dextrous hand and a lamp," he discovered, "not without delight and satisfaction," that the volume of a constant mass of gas varies inversely as the applied pressure; or expressed algebraically, pv = constant.

Then in 1787 followed Charles' law, which, ultimately giving rise to the conception of an absolute zero of temperature, finds its fullest enunciation in the form: the volume of a constant mass of gas at constant pressure is proportional to its absolute temperature, or v = constant $\times$ T.

In 1811 Avogadro laid the foundation of modern chemistry in advancing the hypothesis that equal volumes of gases under like conditions of temperature and pressure contain equal numbers of molecules. Expressed algebraically, molecular weight = 2 $\times$ specific gravity of gas. This hypothesis (raised to the rank of a law by the kinetic theory of gases) lies at the foundation of all the fundamental constants of chemistry—the atomic weights; and till within quite recent times has been the only method of any generality for determining molecular weights, and through these atomic weights.

Graham (1833), following up some of Dobereiner's experiments, which had their origin in a small crack in a glass gas receiver, discovered empirically that the rates of diffusion of gases through very small openings are inversely proportional to the square roots of their specific gravities; or—

$$\frac{\text{Rate of diffusion of } x}{\text{Rate of diffusion of } y} = \frac{\sqrt{\text{Specific gravity } y}}{\sqrt{\text{Specific gravity } x}}$$

Before inquiring what laws, having a chemical bearing, pertain to matter in the liquid state, it will be well to divide liquids into the sub-classes, homogeneous liquids (such as mercury, molten sulphur) and non-homogeneous liquids or solutions (such as solution of sugar in water). It is the latter subdivision with which we have to do.

In 1867, Guldberg and Waage, in enunciating their law to the effect that chemical action which takes place between substances in solution is proportional to the active masses of each of the substances participating in the reaction, laid the foundation of modern concepts regarding chemical affinity.

Quite recently, Raoult in showing that equimolecular solutions (*i. e.*, solutions consisting of quantities of substances proportional to their molecular weights, dissolved in equal quantities of solvent) have the same freezing points and vapor tensions, furnished two new methods of wide applicability for determining molecular weights—methods which can be applied where Avogadro's law fails. Expressed algebraically, Raoult's laws stand as follows:

$$m = \frac{p\,\mathrm{M}\,f^1}{(f-f^1)\,\mathrm{P}} \qquad m = \frac{r\,p}{\Delta\,\mathrm{P}}*$$

The molecular theory of matter has found its greatest development in its application to matter in the gaseous state, that is, as the kinetic theory of gases. Allow that heat is essentially a molecular movement, and that the pressure of a gas is due, not to any specific repulsive forces indwelling in the molecules, but merely to the repeated impacts on the sides of the containing

* Where m = molecular weight to be ascertained, M = molecular weight of solvent, P = weight of solvent, p = weight of dissolved body, f^1 = vapor pressure of solution, f = ditto for solvent, Δ = lowering of freezing point produced by dissolving p grms. of substance in P grms. of solution, and r = constant depending on solvent and determined experimentally for each solvent.

vessel of the heat-impelled molecules, then the laws of Boyle, Charles, Avogadro, and Graham, following as necessary consequences of these postulates, are raised from the low level of mere empiricisms to the higher platform of logical deductions from a theory which, involving only the most simple and probable premises, co-ordinates and explains a vast number of at first apparently disconnected facts.

The question now arises, Are our theories respecting the structure and mechanism of liquids (the case of solids does not concern us in this paper) as definite as the kinetic theory of gases, so that they, in an analogous way, confer warranty on the laws conditioning the properties of liquids? In answer we must reply that up to the present time our views regarding the constitution of homogeneous liquids are so vague as to scarcely merit the name of theories, and that the nature of non-homogeneous liquids or solutions is a burning question of to-day's theoretical chemistry, which is dividing chemist against chemist.

By no means the least result of Van 't Hoff's work on osmotic pressure is the elucidation of the nature, if not of solutions generally, at least of that important class of solutions—the dilute solution, which Raoult and others have experimentally investigated. What is this quantity—osmotic pressure? Suppose a vessel, A, filled with say sugar solution, and immersed completely in water, as in Fig. 1. Further, suppose the

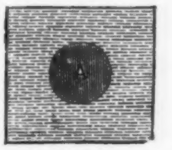


FIG. 1.

walls of A of such a nature that they permit the passage through them of water, but not of sugar molecules. Such walls Van 't Hoff calls *semi-permeable*. In virtue of the attraction of sugar molecules for water molecules water will enter the vessel, A, thereby increasing the pressure on its sides up to a certain limit, when equilibrium is established. This equilibrium pressure in A is called osmotic pressure.

Such *semi-permeable* vessels are realized in practice as follows. The porous cell, A, Fig. 2, filled with a

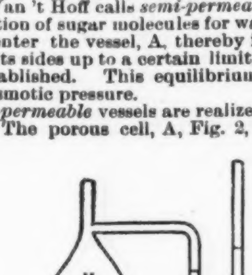


FIG. 2.

solution of potassium ferrocyanide, is immersed in a beaker containing a solution of copper sulphate. The solutions diffusing into the walls of the cell, and meeting about half way, react, forming a precipitate, S, of insoluble copper ferrocyanide, which possesses the semi-permeable qualities alluded to.

In order to take a measure of osmotic pressure with the cell, it is washed out, filled with a solution of known strength of the substance to be investigated, and closed air tight by cementing in the glass head piece, H, which carries the manometer, M. The whole apparatus immersed in a beaker of pure water is allowed to stand till the mercury levels in the manometer cease to change. The difference in height in the levels in the two limbs gives the osmotic pressure.

Accepting this definition of osmotic pressure, Van 't Hoff asserts the existence of a very close and deep seated analogy between gases and substances in dilute solution, provided always in dealing with the analogy we make osmotic pressure in solutions as thus determined correspond to gaseous pressure.

Now Boyle's law states that pressure varies inversely as volume, or what is the same thing, varies directly as concentration. If Van 't Hoff's asserted analogy be valid, the osmotic pressure of a solution should vary directly as its concentration. The following measurements made by Pfeffer shows that Boyle's law *does* hold for dilute solutions, provided osmotic pressure be substituted for gaseous pressure in the ennunciation of the law.

Concentration in percentages.	Osmotic pressure in mm. of mercury.	Ratio: Pressure to Concentration.
1	535	535
2	1,016	508
2·74	1,518	554
4	2,082	521
6	3,075	513

It will be noticed that the figures in the third column, in conformity with Boyle's law, are approximately constant. That Charles' law also holds for dilute solutions has been proved in several ways. I select as the most interesting a physiological method of proof which we owe to De Vries. A leaf—all of such a plant as *Tradescantia discolor* (one of the plants actually used)—consists essentially of an outer cell wall, C, Fig. 3, lined by a layer of protoplasm, the primordial utricle, P; the double envelope forming the boundary of the vacuole, V, which is filled with cell sap.

The living primordial utricle has all the properties of a semi-permeable membrane; consequently, if the cell be immersed in a solution having a greater osmotic pressure than that of the cell sap (due to its contained organic acids and acid salts), water will pass from the sap to the surrounding solution, and the cell will assume a *plasmolytic* condition. That is, the primordial utricle will leave the cell wall, and contract

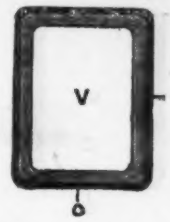


FIG. 3.

on its diminished sap contents, as represented in Fig. 4.

If the concentration of the surrounding solution be so arranged that its osmotic pressure is equal to that of the sap, then there will be no plasmolysis—the primordial utricle will remain in close contact with the cell wall. Of course, if two different solutions are in osmotic equilibrium with the same cell, they must be in osmotic equilibrium with each other. Taking advantage of this behavior of vegetable cells, it has been shown that solutions of common salt, niter, and sugar, which

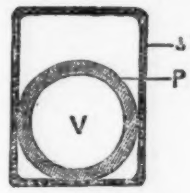


FIG. 4.

exert equal osmotic pressure (*i. e.*, are *isotonic*) at 0°, are isotonic also at 34°. But this is none other than an indirect admission that Charles' law holds also for dilute solutions.

So far as I am aware, dilute solutions have not yet been investigated with respect to Graham's law. With the aid of a cylinder with semi-permeable walls fitted with a piston, we can conceive of various *reversible* processes to which these dilute solutions may be submitted. But that protean and powerful law, the second law of thermodynamics (which states that the energy at our disposal, though unchangeable in amount, is continually approaching a dead level condition in which it will no longer be available), deals with *reversible cycles*, and Van 't Hoff has shown that by applying this second law of thermodynamics to a special reversible process carried out without change of temperature, the necessary consequence is that the osmotic pressure exerted by a dilute solution of a substance is equal to the gaseous pressure which the substance would exert under the same conditions of temperature and concentration. Hence, suppose we have x grms. of a substance dissolved in V volumes of a solvent exerting an osmotic pressure, P, at $t°$; then x grms. of the same substance in the gaseous state, occupying V volumes at $t°$ would exert a gaseous pressure = P.

It is but a short step further to conclude that Avogadro's law holds also for dilute solutions, and that under equal osmotic pressures, and at the same temperature, equal volumes of dilute solutions contain equal numbers of dissolved molecules; and, moreover, the same numbers of molecules which would be contained in equal volumes of gases under like conditions of temperature and pressure. This is Van 't Hoff's *law of osmotic pressure*, which has been amply confirmed by experiment.

But further, assuming the truth of all that has preceded, and applying the second law of thermodynamics to other reversible processes suitably conceived,* and carried out with the cylinder of semi-permeable material; and Van 't Hoff shows that the important laws of Raoult in all their entirety are direct consequences of this analogy between gases and dilute solutions. Nay more, the equations arrived at have new information of their own, and show that the constant r in Raoult'ssecond equation (see *ante*), which up to date has only been determinable by experiment, may be easily calculated from a knowledge of the freezing point and heat of fusion of the solvent; the calculated results agreeing very closely with the experimentally observed results.

By similar methods of reasoning, he has lastly shown that Guldberg and Waage's law (in a slightly modified and more exact form) is a necessary consequence of his development of the conception of osmotic pressure.

Thus we see that the laws relating to dilute solutions, Boyle's law, Charles' law, Raoult's law, Avogadro's law, and Guldberg's law, are not disconnected and independent truths; just as the kinetic theory of gases co-ordinated the laws regulating the deportment of gases, and gave them an imprimatur which they did not before possess, so the analogy worked out by Van 't Hoff has resulted not only in the discovery of new and unsuspected laws for non-homogeneous liquids, but also in the power to group together new and old, and to regard from a common standpoint laws which, having a wide applicability, we are glad to have established and confirmed by theoretical deductions.

No longer do we, in a vague blotting paper impression way, picture to ourselves a dilute aqueous solution of a substance as consisting of various ill-defined hydrates of the dissolved body diffused through the inert excess of solvent; on the contrary, the molecules of the dissolved body retain their individuality just as they would were the body gasified instead of dissolved, with this difference, however, that in the former case the molecules would be separated from one another by the inert ether of space, while in the latter case the molecules are kept outside each other's spheres of action by the intercalated molecules of solvent which are not always inert, but demand the introduction of constants

* For details see translation of Van 't Hoff's paper, i., *Phil. Mag.*, August, 1888.

peculiar to the solvents employed into certain of the equations conditioning the properties of solutions.

In conclusion, let us glance at the fringe of the vast sheet of consequences of Van 't Hoff's analogy. Notable exceptions to Avogadro's law occur among gases. Thus the gas of ammonium chloride under certain conditions exerts a pressure double that which Avogadro's law would lead us to expect under the conditions. Such cases are, as is well known, explained satisfactorily in terms of the theory of dissociation. The question naturally arises: Is the analogy between gases and dilute solutions so perfect that the latter also afford examples of deviation from Avogadro's law explicable in terms of dissociation?

The answer is an affirmative.

A dilute solution of potassium chloride exerts twice the osmotic pressure that theory demands; it is hence concluded that in dilute solution each molecule of KCl is dissociated into its *ions* K and Cl. So startling is this and similar conclusions, that had they not been backed up by scientists of such authority as Ostwald, Van't Hoff, and Arrhenius, I doubt whether they would have ever been granted a fair hearing.

But it must not be supposed that such conclusions rest merely on analogy. Ostwald has described a simple experiment which points to the existence of free ions in a dilute solution of potassium chloride.

Further, it has been noted that those substances which in solution do not conform to Van 't Hoff's law are all electrolytes, while all non-electrolytes obey the law of osmotic pressures. Now, Clausius and Williamson, years ago, suggested that the explanation of electrolysis was to be found in a partial dissociation into their ions of those substances which are electrolyzable. Modern research in defining and confirming their views has shown that the very partial dissociation which these scientists were thought bold for asserting is in reality anything else but partial. In fact, in the case of those substances which we have been in the habit of regarding as most stable (HCl, KCl, KOH, etc.) the dissociation in solution is almost, if not quite, perfect; water completely, or nearly so, separating the molecule of the dissolved substance into its ions. So intimate, indeed, is the relation between electrolysis and osmotic pressure, that the latter quantity for any substance may be fully determined from measurements of the electric conductivity of its aqueous solutions.

Accepting this view of the general existence of dissociation in solution, which has arisen out of Van't Hoff's law of osmotic pressure, many purely chemical facts, hitherto inexplicable, receive a *rationale*. We can now account for Hess' law of thermo-neutrality, which states that the mixture of two neutral salt solutions is unattended by any thermal disturbance; we can now understand why the heats of neutralization of all strong acids are approximately constant; we can conceive of a strong acid displacing a weaker acid from combination without introducing vague views on chemical forces and chimerical attractions; we begin to see through such everyday and familiar experiences as the fact that solution of silver nitrate does not produce a precipitate of silver chloride in all solutions of chlorinated compounds; in short, the development of Van 't Hoff's views leads us to look on many otherwise inexplicable and seemingly isolated phenomena as part and parcel of one vast harmonious system.

"Where order in variety we see,
And where, though all things differ, all agree."

—*Chem. News.*

WHISKY.

IN a communication to the London Society of Chemical Industry Mr. Allen sketched the process of the manufacture of whisky, both in "pot" and patent stills.

In the case of the former the malted and fermented grain is distilled, yielding "low wines," or first liquor and "pot ale," which is run away. As "pot ale" contains about 1 per cent. of acid, mostly lactic acid, it seems probable that a use might be found for it, Mr. Cross stating in the discussion which followed that lactic acid was now made on a large scale from glucose in America, and found a ready sale. "Low wine" is then redistilled, yielding a first fraction called "four shots," then "clean spirit" or actual whisky, next "faints," and, fourthly, spent leys. "Four shots" and "faints" are returned and redistilled, so that finally nothing results but whisky and spent leys. The time to change the receiver is indicated by the "four shots" ceasing to become milky when mixed with an equal bulk of water; again after the whisky has come over the distillate begins once more to give a turbidity on similar treatment, and the era of "faints" begins.

Elgin is the headquarters of the manufacture in Scotland. Irish whisky differs from Scotch by being made partly from unmalted barley. "Potheen" was rightly confined in meaning to whisky made in illicit stills. Its manufacture was almost entirely confined to Ireland, although in 1889 a prosperous concern had been discovered in Birmingham, its prosperity being aided by the fact that the gas used was stolen, by the simple process of tapping a pipe. The genuine potheen was made from mixed and crude materials, molasses being a not uncommon ingredient; sometimes a lump of peat was inserted into the still "for the sake of Ould Oireland!"

The manufacture of patent still spirit consisted in the fermentation and distillation of almost any kind of cheap saccharine matter; the vapors were subjected to a certain amount of fractionation on account of the form of still used, the one most commonly employed being that known as the Coffystill. From this alcohol as strong or stronger than rectified spirit could be obtained, and was termed "silent spirit," as the elimination of impurities was so complete that even an expert could not tell the raw material whence it was derived. In the making of patent still whisky unmixed malt was never used, the least amount necessary to furnish the diastase being deemed sufficient. The product was milder in flavor, and did not alter so much on keeping as pot still whisky. It was contended that such radical difference in mode and cost of manufacture made it very undesirable to permit, as was now done, the blending of pot with patent still whisky, and the vending of the product as "pure malt whisky." As regards the question of fusel oil in whisky, Mr. Allen said that a vast amount of positive and alarmist statements had been founded on the very feeblest basis.

Until within the last few months there were absolutely only four analyses of whisky, giving the percentage of fusel oil, to be found in published records. Mistakes had occurred because Continental observations had been erroneously supposed to touch the matter, the percentages recorded being quite tangible. Whisky, however, was absolutely not made on the Continent, and the published accounts were, therefore, inapplicable.

Then even if it were proved, as his experience showed it was not, that a perceptible amount of fusel oil was present in whisky, it had still to be demonstrated that this constituent was baneful. Mr. Allen had not shrunk from personal experiment; he had nightly for a considerable period drank whisky containing some 2 per cent. of the alleged deadly thing, and beyond its nauseousness had experienced no disagreeable effects. The estimation of fusel oil in the small quantity present in whisky was best effected by distilling the alcohol after saponification with potash, shaking out the diluted spirit with chloroform, oxidizing the higher alcohols to their corresponding acids, and titrating these. Carbon tetrachloride was preferable to chloroform on the whole. A full satisfactory method had not perhaps been arrived at, but every improvement tended to lower the observed percentage.

THE TREATMENT OF TUBERCULOSIS.

LET not our readers be uneasy; it is not a question of treatment by Koch's lymph. The lamentable failure of that business is complete, and there is no occasion to revert to it. But while so much clamor was being raised about this so-called German process, too little attention was paid to the researches modestly elaborated at the Faculty of Paris, and which, applied to therapeutics, stand a chance of being attended with success, and that too without compromising the health and life of patients who exhibit no phenomenon of febrile reaction.

In the month of October, 1888 (it will be seen that the question does not date from yesterday), Mr. Chas. Richet, the young and distinguished professor of physiology of the Faculty, made, in conjunction with Mr. Hericourt, a series of experiments of the greatest interest. Microbes, as well known, do not act in the

STUDY OF THE TREATMENT OF TUBERCULOSIS AT THE PARIS FACULTY OF MEDICINE—INJECTING THE BLOOD OF A DOG INTO A RABBIT.

same way upon the various species of animals. Moreover, there are animals that are absolutely refractory to the inoculation of a microbe that would kill a different species of animal in a few hours. This state of immunity is likely due to the presence in the blood of chemical substances that are poisonous to the microbe and prevent its development. Messrs. Richet and Hericourt asked themselves whether, on injecting into an animal susceptible of being influenced by a microbe the blood of an animal refractory to this same microbe, an immunity would not be obtained for the first. Experiment fully confirmed such a hypothesis.

One microbe that they discovered (*Staphyloccus pyosepticus*) rapidly kills the rabbit and does not act absolutely upon the dog, or produces but a slight local lesion. A certain quantity of the blood of the dog is injected into the peritoneum of the rabbit. The latter is then inoculated with the *Staphylococcus* and resists perfectly. This experiment, many times repeated, proved conclusive. Moreover, this is what was the starting point of a general method which is capable of being put to numerous therapeutical applications.

The idea of applying this first admitted principle to tuberculosis occurred to the minds of the experimenters immediately. They at once set themselves to work and ascertained, in fact, that rabbits transfused with the blood of the dog—an animal refractory to tuberculosis—resisted the inoculations, and remained robust and fat, while the animals not submitted to the operation wasted away and slowly succumbed to the progress of the cachexy. The blood of the dog secured immunity to the rabbits. Was it possible to infer a therapeutical application from these remarkable experiments, which we can summarize but briefly? The question is there put in a different manner. In man, it is not a question, in fact, of rendering him refractory to tuberculosis. The subject is entirely in the power of bacilli. It is a curative and not a prophylatic means that is necessary. Has the blood of the dog such a virtue? The experiments made up to the present do not permit of speaking of a cure, but the improvements have been such that there are here, evidently, researches to be pursued, and which will some day be crowned with success.

The injection of blood into the peritoneum offers certain dangers. It is necessary, moreover, to inject a fixed quantity of it. The method had to be modified. Messrs. Richet and Hericourt found that the globular and fibrinous part was valueless for these experiments, and that the serum was sufficient to secure immunity. They applied themselves to the isolation of the serum from the blood under the most perfect conditions of antisepsy, and were enabled to obtain a pure product, without the least alteration and perfectly innocuous.

It is with the serum of dog's blood—serine—injected subcutaneously, just as an injection of morphine is made, that the first therapeutic applications were made. As we have said, the results have been most encouraging. Some physicians have not feared to make a direct injection into the veins, in order to obtain a quicker result.

What is to be noted is that the improvements have been astonishing, and that, too, without the patient being submitted to the least danger. It should not be thought that the curative agent of phthisis has been definitely found. Neither Mr. Richet nor his co-laborers make the pretension to have pointed out an infallible remedy, which, after a few injections, will suppress a chronic and rebellious disease like phthisis, which is often common to several organs. Such assertions are put forth on the other side of the Rhine only. They say simply: Here is a process that renders animals refractory and that brings about a rapid transformation in man. Study it and observe. It may be inefficacious, that the future will decide, but it is harmless.

We have said that there is here a general method which will find various applications. The proof of it is that two observers at Nantes, Messrs. Bertin and Picq, have attempted the treatment of tuberculosis with the blood of another animal, also refractory. With goat's blood they have obtained in the patients treated an improvement, just as occurs with the use of dog's blood.

The researches of our French scientists have made less stir than those of the Berlin professor. Is it so as not to belie the proverb which has it that no one is a prophet in his own country? Is it not simply that these researches have been conducted with scientific exactness and probity, without dissimulating all the secrets and difficulties of the preparations, and that an endeavor has not been made to start a business and to establish a speculation like that to which the public, and physicians even, have lent themselves with too much ingenuousness.—*Dr. A. Cartaz, in La Nature.*

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